US008636766B2

(12) **United States Patent**
Milliman et al.

(10) **Patent No.: US 8,636,766 B2**
(45) **Date of Patent: Jan. 28, 2014**

(54) **SURGICAL STAPLING APPARATUS INCLUDING SENSING MECHANISM**

(71) Applicant: **Covidien LP**, Mansfield, MA (US)

(72) Inventors: **Keith L. Milliman**, Bethel, CT (US); **Frank J. Viola**, Sandy Hook, CT (US); **Joseph P. Orban**, Norwalk, CT (US); **Randolph F. Lehn**, Stratford, CT (US)

(73) Assignee: **Covidien LP**, Mansfield, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/690,413**

(22) Filed: **Nov. 30, 2012**

(65) **Prior Publication Data**

US 2013/0140342 A1 Jun. 6, 2013

Related U.S. Application Data

(60) Continuation of application No. 13/585,350, filed on Aug. 14, 2012, now Pat. No. 8,342,377, which is a continuation of application No. 13/491,085, filed on Jun. 7, 2012, now Pat. No. 8,292,152, which is a continuation of application No. 13/295,140, filed on Nov. 14, 2011, now Pat. No. 8,256,656, which is a continuation of application No. 13/285,355, filed on Oct. 31, 2011, now Pat. No. 8,210,416, which is a continuation of application No. 12/793,196, filed on Jun. 3, 2010, now Pat. No. 8,070,033, which is a continuation of application No. 12/494,617, filed on Jun. 30, 2009, now Pat. No. 8,083,118, which is a division of application No. 11/974,638, filed on Oct. 15, 2007, now Pat. No. 7,565,993, which is a continuation of application No. 11/489,212, filed on Jul. 19, 2006, now Pat. No. 7,303,107, which is a continuation of application No. 11/186,742, filed on Jul. 20, 2005, now abandoned, which is a continuation

(Continued)

(51) **Int. Cl.**
A61B 17/068 (2006.01)

(52) **U.S. Cl.**
USPC **606/219**; 606/139; 227/19; 227/175.2; 227/176.1

(58) **Field of Classification Search**
USPC 227/19, 175.1, 175.2, 176.1, 180.1; 606/139, 151, 153, 219
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,079,606 A 3/1963 Bobrov et al.
3,490,675 A 1/1970 Green et al.

(Continued)

FOREIGN PATENT DOCUMENTS

AU 198654765 9/1986
DE 2744824 4/1978

(Continued)

OTHER PUBLICATIONS

EP Search Report EP 06023618.9 date of completion Feb. 16, 2007.

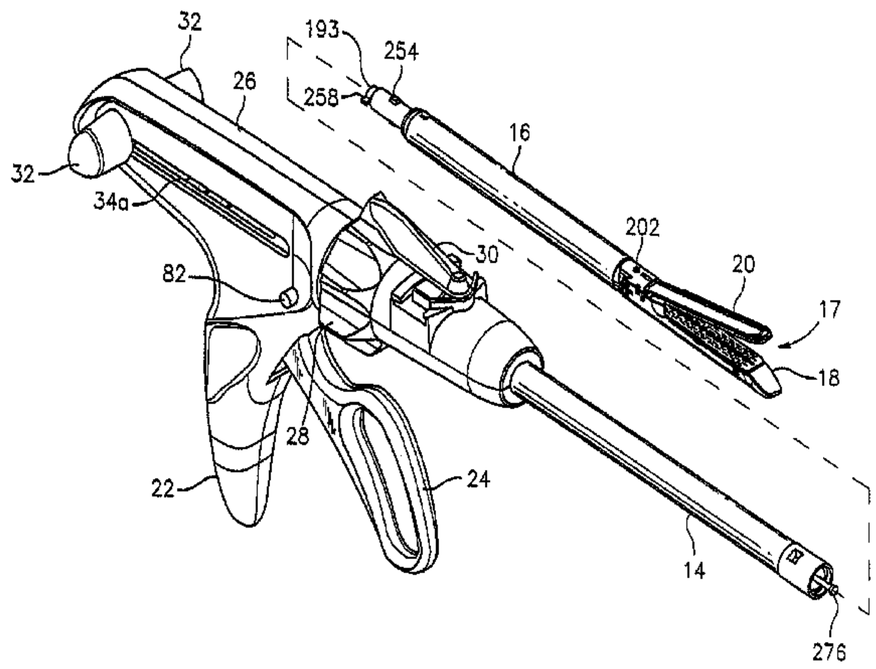
(Continued)

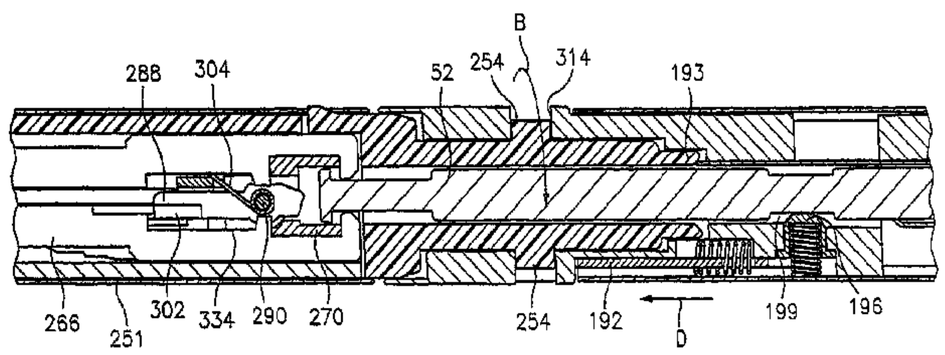
Primary Examiner — Scott A. Smith

(57) **ABSTRACT**

A surgical stapling device particularly suited for endoscopic procedures is described. The device includes a handle assembly and an elongated body extending distally from the handle assembly. The distal end of the elongated body is adapted to engage a disposable loading unit. A control rod having a proximal end operatively connected to the handle assembly includes a distal end extending through the elongated body. A control rod locking member is provided to prevent movement of the control rod until the disposable loading unit is fully secured to the elongated body of the stapling device.

10 Claims, 39 Drawing Sheets





Related U.S. Application Data

of application No. 10/983,288, filed on Nov. 5, 2004, now Pat. No. 6,953,139, which is a continuation of application No. 10/700,250, filed on Nov. 3, 2003, now abandoned, which is a continuation of application No. 10/014,004, filed on Dec. 10, 2001, now Pat. No. 6,669,073, which is a continuation of application No. 09/680,093, filed on Oct. 5, 2000, now Pat. No. 6,330,965, which is a division of application No. 09/561,567, filed on Apr. 28, 2000, now Pat. No. 6,241,139, which is a division of application No. 09/166,378, filed on Oct. 5, 1998, now Pat. No. 6,079,606, which is a division of application No. 08/935,980, filed on Sep. 23, 1997, now Pat. No. 5,865,361.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,499,591	A	3/1970	Green
3,777,538	A	12/1973	Weatherly et al.
3,882,854	A	5/1975	Hulka et al.
4,027,510	A	6/1977	Hiltebrandt
4,086,926	A	5/1978	Green et al.
4,244,372	A	1/1981	Kapitanov et al.
4,429,695	A	2/1984	Green
4,473,077	A	9/1984	Noiles et al.
4,505,414	A	3/1985	Filipi
4,520,817	A	6/1985	Green
4,589,413	A	5/1986	Malyshev et al.
4,596,351	A	6/1986	Fedotov et al.
4,602,634	A	7/1986	Barkley
4,605,001	A	8/1986	Rothfuss et al.
4,608,981	A	9/1986	Rothfuss et al.
4,610,383	A	9/1986	Rothfuss et al.
4,633,861	A	1/1987	Chow et al.
4,633,874	A	1/1987	Chow et al.
4,646,745	A	3/1987	Noiles
4,671,445	A	6/1987	Barker et al.
4,672,964	A	6/1987	Dee et al.
4,700,703	A	10/1987	Resnick et al.
4,703,887	A	11/1987	Clanton et al.
4,728,020	A	3/1988	Green et al.
4,752,024	A	6/1988	Green et al.
4,763,669	A	8/1988	Jaeger
4,784,137	A	11/1988	Kulik et al.
4,863,088	A	9/1989	Redmond et al.
4,869,415	A	9/1989	Fox
4,880,015	A	11/1989	Nierman
4,892,244	A	1/1990	Fox et al.
4,955,959	A	9/1990	Tompkins et al.
4,978,049	A	12/1990	Green
4,991,764	A	2/1991	Mericle
5,014,899	A	5/1991	Presty et al.
5,031,814	A	7/1991	Tompkins et al.
5,040,715	A	8/1991	Green et al.
5,065,929	A	11/1991	Schulze et al.
5,071,052	A	12/1991	Rodak et al.
5,071,430	A	12/1991	deSalis et al.
5,074,454	A	12/1991	Peters
5,083,695	A	1/1992	Foslien et al.
5,084,057	A	1/1992	Green et al.
5,106,008	A	4/1992	Tompkins et al.
5,111,987	A	5/1992	Moeinzadeh et al.
5,129,570	A	7/1992	Schulze et al.
5,141,144	A	8/1992	Foslien et al.
5,152,279	A	10/1992	Wilk
5,156,315	A	10/1992	Green et al.
5,156,614	A	10/1992	Green et al.
5,163,943	A	11/1992	Mohiuddin et al.
5,170,925	A	12/1992	Madden et al.
5,171,247	A	12/1992	Hughetti et al.
5,173,133	A	12/1992	Morin et al.
5,180,092	A	1/1993	Crainich
5,188,274	A	2/1993	Moeinzadeh et al.
5,209,747	A	5/1993	Knoepfler
5,220,928	A	6/1993	Oddsen et al.
5,221,036	A	6/1993	Takase
5,242,457	A	9/1993	Akopov et al.
5,246,156	A	9/1993	Rothfuss et al.
5,253,793	A	10/1993	Green et al.
5,263,629	A	11/1993	Trumbull et al.
RE34,519	E	1/1994	Fox et al.
5,275,323	A	1/1994	Schulze et al.
5,275,608	A	1/1994	Froman et al.
5,282,807	A	2/1994	Knoepfler
5,282,826	A	2/1994	Quadri
5,289,963	A	3/1994	McGarry et al.
5,307,976	A	5/1994	Olson et al.
5,308,576	A	5/1994	Green et al.
5,312,023	A	5/1994	Green et al.
5,318,221	A	6/1994	Green et al.
5,326,013	A	7/1994	Green et al.
5,328,077	A	7/1994	Lou
5,330,486	A	7/1994	Wilk
5,330,502	A	7/1994	Hassler et al.
5,332,142	A	7/1994	Robinson et al.
5,336,232	A	8/1994	Green et al.
5,344,061	A	9/1994	Crainich
5,350,391	A	9/1994	Iacovelli
5,352,238	A	10/1994	Green et al.
5,354,311	A	10/1994	Kambin et al.
5,356,064	A	10/1994	Green et al.
5,358,506	A	10/1994	Green et al.
5,364,001	A	11/1994	Bryan
5,364,002	A	11/1994	Green et al.
5,364,003	A	11/1994	Williamson, IV
5,366,133	A	11/1994	Geiste
5,374,277	A	12/1994	Hassler
5,376,095	A	12/1994	Ortiz
5,379,933	A	1/1995	Green et al.
5,381,943	A	1/1995	Allen et al.
5,382,255	A	1/1995	Castro et al.
5,383,880	A	1/1995	Hooven
5,383,888	A	1/1995	Zvenyatsky et al.
5,389,098	A	2/1995	Tsuruta et al.
5,395,033	A	3/1995	Byrne et al.
5,395,034	A	3/1995	Allen et al.
5,397,046	A	3/1995	Savage et al.
5,397,324	A	3/1995	Carroll et al.
5,403,312	A	4/1995	Yates et al.
5,405,072	A	4/1995	Zlock et al.
5,407,293	A	4/1995	Crainich
5,413,268	A	5/1995	Green et al.
5,415,334	A	5/1995	Williamson, IV et al.
5,415,335	A	5/1995	Knodell, Jr.
5,417,361	A	5/1995	Williamson, IV
5,423,471	A	6/1995	Mastri et al.
5,425,745	A	6/1995	Green et al.
5,431,322	A	7/1995	Green et al.
5,431,323	A	7/1995	Smith et al.
5,433,721	A	7/1995	Hooven et al.
5,441,193	A	8/1995	Gravener
5,445,304	A	8/1995	Plyley et al.
5,447,265	A	9/1995	Vidal et al.
5,452,837	A	9/1995	Williamson, IV et al.
5,456,401	A	10/1995	Green et al.
5,464,300	A	11/1995	Crainich
5,465,895	A	11/1995	Knodel et al.
5,467,911	A	11/1995	Tsuruta et al.
5,470,007	A	11/1995	Plyley et al.
5,470,010	A	11/1995	Rothfuss et al.
5,472,132	A	12/1995	Savage et al.
5,474,566	A	12/1995	Alesi et al.
5,474,571	A	12/1995	Lang
5,476,206	A	12/1995	Green et al.
5,478,003	A	12/1995	Green et al.
5,480,089	A	1/1996	Blewett
5,482,197	A	1/1996	Green et al.
5,484,095	A	1/1996	Green et al.
5,484,451	A	1/1996	Akopov et al.
5,485,947	A	1/1996	Olson et al.
5,485,952	A	1/1996	Fontayne

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,486,185	A	1/1996	Freitas et al.
5,487,499	A	1/1996	Sorrentino et al.
5,487,500	A	1/1996	Knodel et al.
5,489,058	A	2/1996	Plyley et al.
5,490,856	A	2/1996	Person et al.
5,497,933	A	3/1996	DeFonzo et al.
5,501,689	A	3/1996	Green et al.
5,505,363	A	4/1996	Green et al.
5,507,426	A	4/1996	Young et al.
5,518,163	A	5/1996	Hooven
5,518,164	A	5/1996	Hooven
5,529,235	A	6/1996	Boiarski et al.
5,531,744	A	7/1996	Nardella et al.
5,535,934	A	7/1996	Boiarski et al.
5,535,935	A	7/1996	Vidal et al.
5,535,937	A	7/1996	Boiarski et al.
5,540,375	A	7/1996	Bolanos et al.
5,542,594	A	8/1996	McKean et al.
5,549,628	A	8/1996	Cooper et al.
5,551,622	A	9/1996	Yoon
5,553,765	A	9/1996	Knodel et al.
5,554,164	A	9/1996	Wilson et al.
5,554,169	A	9/1996	Green et al.
5,560,530	A	10/1996	Bolanos et al.
5,560,532	A	10/1996	DeFonzo et al.
5,562,239	A	10/1996	Boiarski et al.
5,562,241	A	10/1996	Knodel et al.
5,562,682	A	10/1996	Oberlin et al.
5,562,701	A	10/1996	Huitema et al.
5,564,615	A	10/1996	Bishop et al.
5,571,116	A	11/1996	Bolanos et al.
5,573,169	A	11/1996	Green et al.
5,573,543	A	11/1996	Akopov et al.
5,575,799	A	11/1996	Bolanos et al.
5,575,803	A	11/1996	Cooper et al.
5,577,654	A	11/1996	Bishop
5,579,107	A	11/1996	Wright et al.
5,582,617	A	12/1996	Klieman et al.
5,584,425	A	12/1996	Savage et al.
5,586,711	A	12/1996	Plyley et al.
5,588,580	A	12/1996	Paul et al.
5,588,581	A	12/1996	Conlon et al.
5,597,107	A	1/1997	Knodel et al.
5,601,224	A	2/1997	Bishop et al.
5,605,272	A	2/1997	Witt et al.
5,607,095	A	3/1997	Smith et al.
5,615,820	A	4/1997	Viola
5,618,291	A	4/1997	Thompson et al.
5,624,452	A	4/1997	Yates
5,626,587	A	5/1997	Bishop et al.
5,628,446	A	5/1997	Geiste et al.
5,630,539	A	5/1997	Plyley et al.
5,630,540	A	5/1997	Blewett
5,630,541	A	5/1997	Williamson, IV et al.
5,632,432	A	5/1997	Schulze et al.
5,634,584	A	6/1997	Okorocha et al.
5,636,780	A	6/1997	Green et al.
5,645,209	A	7/1997	Green et al.
5,647,526	A	7/1997	Green et al.
5,651,491	A	7/1997	Heaton et al.
5,653,373	A	8/1997	Green et al.
5,653,374	A	8/1997	Young et al.
5,653,721	A	8/1997	Knodel et al.
5,655,698	A	8/1997	Yoon
5,657,921	A	8/1997	Young et al.
5,658,300	A	8/1997	Bito et al.
5,662,258	A	9/1997	Knodel et al.
5,662,259	A	9/1997	Yoon
5,662,260	A	9/1997	Yoon
5,662,662	A	9/1997	Bishop et al.
5,662,666	A	9/1997	Onuki et al.
5,665,085	A	9/1997	Nardella
5,667,517	A	9/1997	Hooven
5,669,544	A	9/1997	Schulze et al.
5,673,840	A	10/1997	Schulze et al.
5,673,841	A	10/1997	Schulze et al.
5,673,842	A	10/1997	Bittner et al.
5,676,674	A	10/1997	Bolanos et al.
5,680,981	A	10/1997	Mililli et al.
5,680,982	A	10/1997	Schulze et al.
5,680,983	A	10/1997	Plyley et al.
5,690,269	A	11/1997	Bolanos et al.
5,692,668	A	12/1997	Schulze et al.
5,697,542	A	12/1997	Knodel et al.
5,702,409	A	12/1997	Rayburn et al.
5,704,534	A	1/1998	Huitema et al.
5,706,997	A	1/1998	Green et al.
5,709,334	A	1/1998	Sorrentino et al.
5,711,472	A	1/1998	Bryan
5,713,505	A	2/1998	Huitema
5,715,988	A	2/1998	Palmer
5,716,366	A	2/1998	Yates
5,718,359	A	2/1998	Palmer
5,725,536	A	3/1998	Oberlin et al.
5,725,554	A	3/1998	Simon et al.
5,728,110	A	3/1998	Vidal et al.
5,732,806	A	3/1998	Foshee et al.
5,735,848	A	4/1998	Yates et al.
5,743,456	A	4/1998	Jones et al.
5,749,893	A	5/1998	Vidal et al.
5,752,644	A	5/1998	Bolanos et al.
5,762,255	A	6/1998	Chrisman et al.
5,762,256	A	6/1998	Mastri et al.
5,769,303	A	6/1998	Knodel et al.
5,769,892	A	6/1998	Kingwell
5,772,099	A	6/1998	Gravener
5,772,673	A	6/1998	Cuny et al.
5,779,130	A	7/1998	Alesi et al.
5,779,131	A	7/1998	Knodel et al.
5,779,132	A	7/1998	Knodel et al.
5,782,396	A	7/1998	Mastri et al.
5,782,397	A	7/1998	Koukline
5,782,834	A	7/1998	Lucey et al.
5,785,232	A	7/1998	Vidal et al.
5,797,536	A	8/1998	Smith et al.
5,797,537	A	8/1998	Oberlin et al.
5,797,538	A	8/1998	Heaton et al.
5,810,811	A	9/1998	Yates et al.
5,810,855	A	9/1998	Rayburn et al.
5,814,055	A	9/1998	Knodel et al.
5,814,057	A	9/1998	Oi et al.
5,816,471	A	10/1998	Plyley et al.
5,817,109	A	10/1998	McGarry et al.
5,820,009	A	10/1998	Melling et al.
5,823,066	A	10/1998	Huitema et al.
5,826,776	A	10/1998	Schulze et al.
5,829,662	A	11/1998	Allen et al.
5,833,695	A	11/1998	Yoon
5,836,147	A	11/1998	Schnipke
5,855,311	A	1/1999	Hamblin et al.
5,862,972	A	1/1999	Green et al.
5,865,361	A	2/1999	Milliman et al.
5,871,135	A	2/1999	Williamson, IV et al.
5,873,873	A	2/1999	Smith et al.
5,878,938	A	3/1999	Bittner et al.
5,893,506	A	4/1999	Powell
5,894,979	A	4/1999	Powell
5,897,562	A	4/1999	Bolanos et al.
5,901,895	A	5/1999	Heaton et al.
5,911,352	A	6/1999	Racenet et al.
5,911,353	A	6/1999	Bolanos et al.
5,918,791	A	7/1999	Sorrentino et al.
5,919,198	A	7/1999	Graves, Jr. et al.
5,922,001	A	7/1999	Yoon
5,931,847	A	8/1999	Bittner et al.
5,941,442	A	8/1999	Geiste et al.
5,954,259	A	9/1999	Viola et al.
5,964,774	A	10/1999	McKean et al.
5,980,510	A	11/1999	Tsonton et al.
5,988,479	A	11/1999	Palmer
6,004,335	A	12/1999	Vaitekunas et al.
6,010,054	A	1/2000	Johnson et al.
6,032,849	A	3/2000	Mastri et al.
6,045,560	A	4/2000	McKean et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,063,097	A	5/2000	Oi et al.
6,079,606	A	6/2000	Milliman et al.
6,099,551	A	8/2000	Gabbay
6,109,500	A	8/2000	Alli et al.
6,131,789	A	10/2000	Schulze et al.
6,131,790	A	10/2000	Piraka
6,155,473	A	12/2000	Tompkins et al.
6,197,017	B1	3/2001	Brock et al.
6,202,914	B1	3/2001	Geiste et al.
6,241,139	B1	6/2001	Milliman et al.
6,250,532	B1	6/2001	Green et al.
6,264,086	B1	7/2001	McGuckin, Jr.
6,264,087	B1	7/2001	Whitman
6,269,977	B1	8/2001	Moore
6,279,809	B1	8/2001	Nicolo
6,315,183	B1	11/2001	Piraka
6,315,184	B1	11/2001	Whitman
6,325,810	B1	12/2001	Hamilton et al.
6,330,965	B1	12/2001	Milliman et al.
6,391,038	B2	5/2002	Vargas et al.
6,398,797	B2	6/2002	Bombard et al.
6,436,097	B1	8/2002	Nardella
6,439,446	B1	8/2002	Perry et al.
6,443,973	B1	9/2002	Whitman
6,463,623	B2	10/2002	Ahn et al.
6,478,804	B2	11/2002	Vargas et al.
6,488,196	B1	12/2002	Fenton, Jr.
6,503,257	B2	1/2003	Grant et al.
6,503,259	B2	1/2003	Huxel et al.
6,505,768	B2	1/2003	Whitman
6,544,274	B2	4/2003	Danitz et al.
6,554,844	B2	4/2003	Lee et al.
6,565,554	B1	5/2003	Niemeyer
6,587,750	B2	7/2003	Gerbi et al.
6,592,597	B2	7/2003	Grant et al.
6,594,552	B1	7/2003	Nowlin et al.
6,602,252	B2	8/2003	Mollenauer
6,612,053	B2	9/2003	Liao
6,619,529	B2	9/2003	Green et al.
D480,808	S	10/2003	Wells et al.
6,644,532	B2	11/2003	Green et al.
6,656,193	B2	12/2003	Grant et al.
6,669,073	B2	12/2003	Milliman et al.
6,681,978	B2	1/2004	Geiste et al.
6,698,643	B2	3/2004	Whitman
6,716,232	B1	4/2004	Vidal et al.
6,722,552	B2	4/2004	Fenton, Jr.
6,731,473	B2	5/2004	Li et al.
6,755,338	B2	6/2004	Hahnen et al.
6,783,524	B2	8/2004	Anderson et al.
6,786,382	B1	9/2004	Hoffman
6,808,262	B2	10/2004	Chapoy et al.
6,817,509	B2	11/2004	Geiste et al.
6,830,174	B2	12/2004	Hillstead et al.
6,835,199	B2	12/2004	McGuckin, Jr. et al.
6,843,403	B2	1/2005	Whitman
RE38,708	E	3/2005	Bolanos et al.
6,877,647	B2	4/2005	Green et al.
6,879,880	B2	4/2005	Nowlin et al.
6,889,116	B2	5/2005	Jinno
6,905,057	B2	6/2005	Swayze et al.
6,945,444	B2	9/2005	Gresham
6,953,138	B1	10/2005	Dworak et al.
6,953,139	B2	10/2005	Milliman et al.
6,959,852	B2	11/2005	Shelton, IV et al.
6,962,594	B1	11/2005	Thevenet
6,964,363	B2	11/2005	Wales et al.
6,978,921	B2	12/2005	Shelton, IV et al.
6,981,628	B2	1/2006	Wales
6,986,451	B1	1/2006	Mastri et al.
6,988,649	B2	1/2006	Shelton, IV et al.
6,991,627	B2	1/2006	Madhani et al.
6,994,714	B2	2/2006	Vargas et al.
7,000,818	B2	2/2006	Shelton, IV et al.
7,000,819	B2	2/2006	Swayze et al.
7,032,799	B2	4/2006	Viola et al.
7,044,352	B2	5/2006	Shelton, IV et al.
7,044,353	B2	5/2006	Mastri et al.
7,055,730	B2	6/2006	Ehrenfels et al.
7,055,731	B2	6/2006	Shelton, IV et al.
7,059,508	B2	6/2006	Shelton, IV et al.
7,070,083	B2	7/2006	Jankowski
7,083,075	B2	8/2006	Swayze et al.
7,097,089	B2	8/2006	Marczyk
7,111,769	B2	9/2006	Wales et al.
7,114,642	B2	10/2006	Whitman
7,121,446	B2	10/2006	Arad et al.
7,128,253	B2	10/2006	Mastri et al.
7,128,254	B2	10/2006	Shelton, IV et al.
7,140,527	B2	11/2006	Ehrenfels et al.
7,140,528	B2	11/2006	Shelton, IV
7,143,923	B2	12/2006	Shelton, IV et al.
7,143,924	B2	12/2006	Scirica et al.
7,143,925	B2	12/2006	Shelton, IV et al.
7,143,926	B2	12/2006	Shelton, IV et al.
7,147,138	B2	12/2006	Shelton, IV
7,159,750	B2	1/2007	Racenet et al.
7,168,604	B2	1/2007	Milliman
7,172,104	B2	2/2007	Scirica et al.
7,188,758	B2	3/2007	Viola et al.
7,207,471	B2	4/2007	Heinrich et al.
7,213,736	B2	5/2007	Wales et al.
7,225,963	B2	6/2007	Scirica
7,225,964	B2	6/2007	Mastri et al.
7,238,195	B2	7/2007	Viola
7,246,734	B2	7/2007	Shelton, IV
7,258,262	B2	8/2007	Mastri et al.
7,278,562	B2	10/2007	Mastri et al.
7,278,563	B1	10/2007	Green
7,287,682	B1	10/2007	Ezzat et al.
7,293,685	B2	11/2007	Ehrenfels et al.
7,296,722	B2	11/2007	Ivanko
7,296,724	B2	11/2007	Green et al.
7,296,772	B2	11/2007	Wang
7,300,444	B1	11/2007	Nielsen et al.
7,303,107	B2	12/2007	Milliman et al.
7,303,108	B2	12/2007	Shelton, IV
7,308,998	B2	12/2007	Mastri et al.
7,326,232	B2	2/2008	Viola et al.
7,328,828	B2	2/2008	Ortiz et al.
7,328,829	B2	2/2008	Arad et al.
7,334,717	B2	2/2008	Rethy et al.
7,354,447	B2	4/2008	Shelton, IV et al.
7,357,287	B2	4/2008	Shelton, IV et al.
7,364,061	B2	4/2008	Swayze et al.
7,367,485	B2	5/2008	Shelton, IV et al.
7,377,928	B2	5/2008	Zubik et al.
7,380,695	B2	6/2008	Doll et al.
7,380,696	B2	6/2008	Shelton, IV et al.
7,396,356	B2	7/2008	Mollenauer
7,398,907	B2	7/2008	Racenet et al.
7,399,310	B2	7/2008	Edoga et al.
7,401,720	B1	7/2008	Durrani
7,401,721	B2	7/2008	Holsten et al.
7,404,508	B2	7/2008	Smith et al.
7,404,509	B2	7/2008	Ortiz et al.
7,407,074	B2	8/2008	Ortiz et al.
7,407,075	B2	8/2008	Holsten et al.
7,407,077	B2	8/2008	Ortiz et al.
7,407,078	B2	8/2008	Shelton, IV et al.
7,416,101	B2	8/2008	Shelton, IV et al.
7,419,080	B2	9/2008	Smith et al.
7,419,081	B2	9/2008	Ehrenfels et al.
7,419,495	B2	9/2008	Menn et al.
7,422,139	B2	9/2008	Shelton, IV et al.
7,424,965	B2	9/2008	Racenet et al.
7,431,189	B2	10/2008	Shelton, IV et al.
7,431,730	B2	10/2008	Viola
7,434,715	B2	10/2008	Shelton, IV et al.
7,434,717	B2	10/2008	Shelton, IV et al.
7,438,208	B2	10/2008	Larson
7,438,209	B1	10/2008	Hess et al.
7,441,684	B2	10/2008	Shelton, IV et al.
7,441,685	B1	10/2008	Boudreaux

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,448,525 B2 11/2008 Shelton, IV et al.
7,451,904 B2 11/2008 Shelton, IV
7,455,208 B2 11/2008 Wales et al.
7,455,676 B2 11/2008 Holsten et al.
7,458,494 B2 12/2008 Matsutani et al.
7,461,767 B2 12/2008 Viola et al.
7,462,185 B1 12/2008 Knodel
7,464,846 B2 12/2008 Shelton, IV et al.
7,464,847 B2 12/2008 Viola et al.
7,464,848 B2 12/2008 Green et al.
7,464,849 B2 12/2008 Shelton, IV et al.
7,467,740 B2 12/2008 Shelton, IV et al.
7,472,814 B2 1/2009 Mastri et al.
7,472,815 B2 1/2009 Shelton, IV et al.
7,472,816 B2 1/2009 Holsten et al.
7,473,258 B2 1/2009 Clauson et al.
7,481,347 B2 1/2009 Roy
7,481,348 B2 1/2009 Marczyk
7,481,349 B2 1/2009 Holsten et al.
7,481,824 B2 1/2009 Gillum et al.
7,487,899 B2 2/2009 Shelton, IV et al.
7,490,749 B2 2/2009 Schall et al.
7,494,039 B2 2/2009 Racenet et al.
7,500,979 B2 3/2009 Hueil et al.
7,503,474 B2 3/2009 Hillstead et al.
7,506,790 B2 3/2009 Shelton, IV
7,506,791 B2 3/2009 Omaits et al.
7,510,107 B2 3/2009 Timm et al.
7,513,408 B2 4/2009 Shelton, IV et al.
7,517,356 B2 4/2009 Heinrich
7,537,602 B2 5/2009 Whitman
7,543,729 B2 6/2009 Ivanko
7,543,730 B1 6/2009 Marczyk
7,543,731 B2 6/2009 Green et al.
7,552,854 B2 6/2009 Wixey et al.
7,556,185 B2 7/2009 Viola
7,556,186 B2 7/2009 Milliman
7,559,450 B2 7/2009 Wales et al.
7,559,452 B2 7/2009 Wales et al.
7,559,453 B2 7/2009 Heinrich et al.
7,559,937 B2 7/2009 de la Torre et al.
7,565,993 B2 7/2009 Milliman et al.
7,568,603 B2 8/2009 Shelton, IV et al.
7,568,604 B2 8/2009 Ehrenfels et al.
7,571,845 B2 8/2009 Viola
7,575,144 B2 8/2009 Ortiz et al.
7,584,880 B2 9/2009 Racenet et al.
7,588,174 B2 9/2009 Holsten et al.
7,588,175 B2 9/2009 Timm et al.
7,588,176 B2 9/2009 Timm et al.
7,588,177 B2 9/2009 Racenet
7,597,229 B2 10/2009 Boudreaux et al.
7,597,230 B2 10/2009 Racenet et al.
7,600,663 B2 10/2009 Green
7,604,150 B2 10/2009 Boudreaux
7,604,151 B2 10/2009 Hess et al.
7,607,557 B2 10/2009 Shelton, IV et al.
7,611,038 B2 11/2009 Racenet et al.
7,617,961 B2 11/2009 Viola
7,624,902 B2 12/2009 Marczyk et al.
7,624,903 B2 12/2009 Green et al.
7,631,793 B2 12/2009 Rethy et al.
7,631,794 B2 12/2009 Rethy et al.
7,635,073 B2 12/2009 Heinrich
7,635,074 B2 12/2009 Olson et al.
7,635,373 B2 12/2009 Ortiz
7,637,409 B2 12/2009 Marczyk
7,637,410 B2 12/2009 Marczyk
7,641,091 B2 1/2010 Olson et al.
7,641,093 B2 1/2010 Doll et al.
7,641,095 B2 1/2010 Viola
7,644,848 B2 1/2010 Swayze et al.
7,648,055 B2 1/2010 Marczyk
7,651,017 B2 1/2010 Ortiz et al.
7,654,431 B2 2/2010 Hueil et al.
7,658,311 B2 2/2010 Boudreaux
7,658,312 B2 2/2010 Vidal et al.
7,665,646 B2 2/2010 Prommersberger
7,665,647 B2 2/2010 Shelton, IV et al.
7,669,746 B2 3/2010 Shelton, IV
7,670,334 B2 3/2010 Hueil et al.
7,673,780 B2 3/2010 Shelton, IV et al.
7,673,781 B2 3/2010 Swayze et al.
7,673,782 B2 3/2010 Hess et al.
7,673,783 B2 3/2010 Morgan et al.
7,678,121 B1 3/2010 Knodel
7,681,772 B2 3/2010 Green et al.
7,682,367 B2 3/2010 Shah et al.
7,682,368 B1 3/2010 Bombard et al.
7,690,547 B2 4/2010 Racenet et al.
7,694,865 B2 4/2010 Scirica
7,699,205 B2 4/2010 Ivanko
7,703,653 B2 4/2010 Shah et al.
7,721,930 B2 5/2010 McKenna et al.
7,721,931 B2 5/2010 Shelton et al.
7,721,933 B2 5/2010 Ehrenfels et al.
7,721,935 B2 5/2010 Racenet et al.
7,726,537 B2 6/2010 Olson et al.
7,726,538 B2 6/2010 Holsten et al.
7,726,539 B2 6/2010 Holsten et al.
7,731,072 B2 6/2010 Timm et al.
7,735,703 B2 6/2010 Morgan et al.
7,740,159 B2 6/2010 Shelton et al.
7,740,160 B2 6/2010 Viola
7,743,960 B2 6/2010 Whitman
7,744,628 B2 6/2010 Viola
7,753,245 B2 7/2010 Boudreaux et al.
7,753,248 B2 7/2010 Viola
7,757,924 B2 7/2010 Gerbi et al.
7,757,925 B2 7/2010 Viola et al.
7,762,445 B2 7/2010 Heinrich et al.
7,766,209 B2 8/2010 Baxter, III et al.
7,766,210 B2 8/2010 Shelton, IV et al.
7,766,924 B1 8/2010 Bombard et al.
7,766,928 B2 8/2010 Ezzat et al.
7,770,774 B2 8/2010 Mastri et al.
7,770,775 B2 8/2010 Shelton, IV et al.
7,776,060 B2 8/2010 Mooradian et al.
7,780,055 B2 8/2010 Scirica et al.
7,784,662 B2 8/2010 Wales et al.
7,789,283 B2 9/2010 Shah
7,789,889 B2 9/2010 Zubik et al.
7,793,812 B2 9/2010 Moore et al.
7,793,814 B2 9/2010 Racenet et al.
7,794,475 B2 9/2010 Hess et al.
7,798,385 B2 9/2010 Boyden et al.
7,798,386 B2 9/2010 Schall et al.
7,799,039 B2 9/2010 Shelton, IV et al.
7,810,690 B2 10/2010 Bilotti et al.
7,810,691 B2 10/2010 Boyden et al.
7,810,692 B2 10/2010 Hall et al.
7,810,693 B2 10/2010 Broehl et al.
7,815,090 B2 10/2010 Marczyk
7,815,091 B2 10/2010 Marczyk
7,815,092 B2 10/2010 Whitman et al.
7,819,296 B2 10/2010 Hueil et al.
7,819,297 B2 10/2010 Doll et al.
7,819,298 B2 10/2010 Hall et al.
7,819,299 B2 10/2010 Shelton, IV et al.
7,819,896 B2 10/2010 Racenet
7,823,760 B2 11/2010 Zemlok et al.
7,823,761 B2 11/2010 Boyden et al.
7,824,426 B2 11/2010 Racenet et al.
7,828,186 B2 11/2010 Wales
7,828,187 B2 11/2010 Green et al.
7,828,188 B2 11/2010 Jankowski
7,828,189 B2 11/2010 Holsten et al.
7,832,408 B2 11/2010 Shelton, IV et al.
7,832,611 B2 11/2010 Boyden et al.
7,832,612 B2 11/2010 Baxter, III et al.
7,837,079 B2 11/2010 Holsten et al.
7,837,081 B2 11/2010 Holsten et al.
7,841,503 B2 11/2010 Sonnenschein et al.
7,845,533 B2 12/2010 Marczyk et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,845,534 B2 12/2010 Viola et al.
7,845,535 B2 12/2010 Scircia
7,845,537 B2 12/2010 Shelton, IV et al.
7,845,538 B2 12/2010 Whitman
7,850,703 B2 12/2010 Bombard et al.
7,857,183 B2 12/2010 Shelton, IV
7,857,184 B2 12/2010 Viola
7,857,185 B2 12/2010 Swayze et al.
7,857,186 B2 12/2010 Baxter, III et al.
7,861,906 B2 1/2011 Doll et al.
7,861,907 B2 1/2011 Green et al.
7,866,524 B2 1/2011 Krehel
7,866,525 B2 1/2011 Scirica
7,866,526 B2 1/2011 Green et al.
7,866,527 B2 1/2011 Hall et al.
7,866,528 B2 1/2011 Olson et al.
7,870,989 B2 1/2011 Viola et al.
7,886,952 B2 2/2011 Scirica et al.
7,891,532 B2 2/2011 Mastri et al.
7,891,533 B2 2/2011 Green et al.
7,891,534 B2 2/2011 Wenchell et al.
7,896,214 B2 3/2011 Farascioni
7,900,805 B2 3/2011 Shelton, IV et al.
7,901,416 B2 3/2011 Nolan et al.
7,905,380 B2 3/2011 Shelton, IV et al.
7,905,381 B2 3/2011 Baxter, III et al.
7,909,039 B2 3/2011 Hur
7,909,220 B2 3/2011 Viola
7,909,221 B2 3/2011 Viola et al.
7,909,224 B2 3/2011 Prommersberger
7,913,891 B2 3/2011 Doll et al.
7,913,893 B2 3/2011 Mastri et al.
7,914,543 B2 3/2011 Roth et al.
7,918,230 B2 4/2011 Whitman et al.
7,918,276 B2 4/2011 Guignard et al.
7,922,061 B2 4/2011 Shelton, IV et al.
7,922,063 B2 4/2011 Zemlok et al.
7,922,064 B2 4/2011 Boyden et al.
7,926,691 B2 4/2011 Viola et al.
7,926,692 B2 4/2011 Racenet et al.
7,934,628 B2 5/2011 Wenchell et al.
7,934,630 B2 5/2011 Shelton, Iv et al.
7,934,631 B2 5/2011 Balbierz et al.
7,942,300 B2 5/2011 Rethy et al.
7,942,303 B2 5/2011 Shah
7,950,560 B2 5/2011 Zemlok et al.
7,950,561 B2 5/2011 Aranyi
7,950,562 B2 5/2011 Beardsley et al.
7,954,682 B2 6/2011 Giordano et al.
7,954,683 B1 6/2011 Knodel et al.
7,954,684 B2 6/2011 Boudreaux
7,954,685 B2 6/2011 Viola
7,954,686 B2 6/2011 Baxter, III et al.
7,954,687 B2 6/2011 Zemlok et al.
7,959,051 B2 6/2011 Smith et al.
7,963,431 B2 6/2011 Scirica
7,963,432 B2 6/2011 Knodel et al.
7,963,433 B2 6/2011 Whitman et al.
7,967,178 B2 6/2011 Scirica et al.
7,967,179 B2 6/2011 Olson et al.
7,967,180 B2 6/2011 Scirica
7,975,894 B2 7/2011 Boyden et al.
7,980,443 B2 7/2011 Scheib et al.
7,988,026 B2 8/2011 Knodel et al.
7,988,027 B2 8/2011 Olson et al.
7,988,028 B2 8/2011 Farascioni et al.
7,992,758 B2 8/2011 Whitman et al.
7,997,468 B2 8/2011 Farascioni
7,997,469 B2 8/2011 Olson et al.
8,002,795 B2 8/2011 Beetel
8,006,885 B2 8/2011 Marczyk
8,006,887 B2 8/2011 Marczyk
8,007,505 B2 8/2011 Weller et al.
8,007,513 B2 8/2011 Nalagatla et al.
8,011,550 B2 9/2011 Aranyi et al.
8,011,551 B2 9/2011 Marczyk et al.
8,011,552 B2 9/2011 Ivanko
8,011,553 B2 9/2011 Mastri et al.
8,011,555 B2 9/2011 Tarinelli et al.
8,012,170 B2 9/2011 Whitman et al.
8,015,976 B2 9/2011 Shah
8,016,177 B2 9/2011 Bettuchi et al.
8,016,178 B2 9/2011 Olson et al.
8,020,742 B2 9/2011 Marczyk
8,020,743 B2 9/2011 Shelton, IV
8,028,882 B2 10/2011 Viola
8,028,883 B2 10/2011 Stopek
8,028,884 B2 10/2011 Sniffin et al.
8,033,438 B2 10/2011 Scirica
8,033,440 B2 10/2011 Wenchell et al.
8,033,441 B2 10/2011 Marczyk
8,033,442 B2 10/2011 Racenet et al.
8,034,077 B2 10/2011 Smith et al.
8,038,044 B2 10/2011 Viola
8,038,045 B2 10/2011 Bettuchi et al.
8,052,024 B2 11/2011 Viola et al.
8,056,787 B2 11/2011 Boudreaux et al.
8,056,788 B2 11/2011 Mastri et al.
8,056,791 B2 11/2011 Whitman
8,061,577 B2 11/2011 Racenet et al.
8,066,166 B2 11/2011 Demmy et al.
8,070,033 B2 12/2011 Milliman et al.
8,070,035 B2 12/2011 Holsten et al.
8,074,858 B2 12/2011 Marczyk
8,074,859 B2 12/2011 Kostrzewski
8,074,862 B2 12/2011 Shah
8,083,118 B2 12/2011 Milliman et al.
8,083,119 B2 12/2011 Prommersberger
8,083,120 B2 12/2011 Shelton et al.
8,087,563 B2 1/2012 Milliman et al.
8,091,753 B2 1/2012 Viola
8,091,754 B2 1/2012 Ehrenfels et al.
8,091,756 B2 1/2012 Viola
8,096,459 B2 1/2012 Ortiz et al.
8,096,460 B2 1/2012 Blier et al.
8,100,309 B2 1/2012 Marczyk
8,100,310 B2 1/2012 Zemlok
8,113,406 B2 2/2012 Holsten et al.
8,113,407 B2 2/2012 Holsten et al.
8,113,408 B2 2/2012 Wenchell et al.
8,113,409 B2 2/2012 Cohen et al.
8,113,410 B2 2/2012 Hall et al.
8,123,101 B2 2/2012 Racenet et al.
8,127,975 B2 3/2012 Olson et al.
8,127,976 B2 3/2012 Scirica et al.
8,132,703 B2 3/2012 Milliman et al.
8,132,705 B2 3/2012 Viola et al.
8,132,706 B2 3/2012 Marczyk et al.
8,136,713 B2 3/2012 Hathaway et al.
8,141,762 B2 3/2012 Bedi et al.
8,152,041 B2 4/2012 Kostrzewski
8,157,148 B2 4/2012 Scirica
8,157,151 B2 4/2012 Ingmanson et al.
8,167,185 B2 5/2012 Shelton, IV et al.
8,167,186 B2 5/2012 Racenet et al.
8,172,121 B2 5/2012 Krehel
8,172,124 B2 5/2012 Shelton, IV et al.
8,181,837 B2 5/2012 Roy
8,186,555 B2 5/2012 Shelton, IV et al.
8,186,558 B2 5/2012 Sapienza
8,186,560 B2 5/2012 Hess et al.
8,196,795 B2 6/2012 Moore et al.
8,196,796 B2 6/2012 Shelton, IV et al.
8,205,619 B2 6/2012 Shah et al.
8,205,780 B2 6/2012 Sorrentino et al.
8,205,781 B2 6/2012 Baxter, III et al.
8,210,416 B2 7/2012 Milliman et al.
8,216,236 B2 7/2012 Heinrich et al.
8,220,688 B2 7/2012 Laurent et al.
8,220,690 B2 7/2012 Hess et al.
8,225,979 B2 7/2012 Farascioni et al.
8,231,040 B2 7/2012 Zemlok et al.
8,231,041 B2 7/2012 Marczyk et al.
8,235,272 B2 8/2012 Nicholas et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,236,010	B2	8/2012	Ortiz et al.	
8,241,322	B2	8/2012	Whitman et al.	
8,245,897	B2	8/2012	Tzakis et al.	
8,245,898	B2	8/2012	Smith et al.	
8,245,899	B2	8/2012	Swensgard et al.	
8,252,009	B2	8/2012	Weller et al.	
8,256,656	B2 *	9/2012	Milliman et al.	227/180.1
8,267,300	B2	9/2012	Boudreaux	
8,272,554	B2	9/2012	Whitman et al.	
8,292,152	B2 *	10/2012	Milliman et al.	227/175.1
8,342,377	B2 *	1/2013	Milliman et al.	227/175.2
2004/0108357	A1	6/2004	Milliman	
2004/0199180	A1	10/2004	Knodel et al.	
2004/0199181	A1	10/2004	Knodel et al.	
2004/0232201	A1	11/2004	Wenchell	
2004/0243151	A1	12/2004	Demmy	
2004/0267310	A1	12/2004	Racenet	
2005/0103819	A1	5/2005	Racenet	
2005/0119669	A1	6/2005	Demmy	
2005/0189397	A1	9/2005	Jankowski	
2005/0216055	A1	9/2005	Scirica et al.	
2006/0049229	A1	3/2006	Milliman et al.	
2006/0180634	A1	8/2006	Shelton, IV et al.	
2006/0289602	A1	12/2006	Wales et al.	
2007/0027469	A1	2/2007	Smith et al.	
2007/0073341	A1	3/2007	Smith et al.	
2007/0084897	A1	4/2007	Shelton, IV et al.	
2007/0084899	A1	4/2007	Taylor	
2007/0102472	A1	5/2007	Shelton, IV	
2007/0106317	A1	5/2007	Shelton, IV	
2007/0119901	A1	5/2007	Ehrenfels et al.	
2007/0145096	A1	6/2007	Viola et al.	
2007/0170225	A1	7/2007	Shelton, IV et al.	
2007/0175949	A1	8/2007	Shelton, IV et al.	
2007/0175950	A1	8/2007	Shelton, IV et al.	
2007/0175951	A1	8/2007	Shelton, IV et al.	
2007/0175955	A1	8/2007	Shelton, IV et al.	
2007/0179528	A1	8/2007	Soltz et al.	
2007/0194079	A1	8/2007	Hueil et al.	
2007/0194081	A1	8/2007	Hueil et al.	
2007/0194082	A1	8/2007	Morgan et al.	
2007/0221700	A1	9/2007	Ortiz et al.	
2007/0295780	A1	12/2007	Shelton et al.	
2008/0029570	A1	2/2008	Shelton et al.	
2008/0029573	A1	2/2008	Shelton et al.	
2008/0029574	A1	2/2008	Shelton et al.	
2008/0029575	A1	2/2008	Shelton et al.	
2008/0078800	A1	4/2008	Hess et al.	
2008/0078802	A1	4/2008	Hess et al.	
2008/0078803	A1	4/2008	Shelton et al.	
2008/0078804	A1	4/2008	Shelton et al.	
2008/0078806	A1	4/2008	Omaits et al.	
2008/0078808	A1	4/2008	Hess et al.	
2008/0110961	A1	5/2008	Voegele et al.	
2008/0149685	A1	6/2008	Smith et al.	
2008/0169328	A1	7/2008	Shelton	
2008/0169329	A1	7/2008	Shelton et al.	
2008/0169330	A1	7/2008	Shelton et al.	
2008/0169331	A1	7/2008	Shelton et al.	
2008/0169332	A1	7/2008	Shelton et al.	
2008/0169333	A1	7/2008	Shelton et al.	
2008/0287987	A1	11/2008	Boyden et al.	
2008/0296344	A1	12/2008	Cropper et al.	
2008/0296346	A1	12/2008	Shelton, IV et al.	
2008/0308602	A1	12/2008	Timm et al.	
2008/0308603	A1	12/2008	Shelton, IV et al.	
2009/0001121	A1	1/2009	Hess et al.	
2009/0001124	A1	1/2009	Hess et al.	
2009/0001130	A1	1/2009	Hess et al.	
2009/0005808	A1	1/2009	Hess et al.	
2009/0065549	A1	3/2009	Viola	
2009/0078739	A1	3/2009	Viola	
2009/0090763	A1	4/2009	Zemlok et al.	
2009/0090766	A1	4/2009	Knodel	
2009/0209946	A1	8/2009	Swayze et al.	
2009/0209990	A1	8/2009	Yates et al.	
2009/0236395	A1	9/2009	Scirica	
2009/0242610	A1	10/2009	Shelton, IV et al.	
2009/0255974	A1	10/2009	Viola	
2009/0272787	A1	11/2009	Scirica	
2009/0277946	A1	11/2009	Marczyk	
2009/0277949	A1	11/2009	Viola et al.	
2009/0283568	A1	11/2009	Racenet et al.	
2009/0306708	A1	12/2009	Shah	
2009/0308907	A1	12/2009	Nalagatla et al.	
2010/0012703	A1	1/2010	Calabrese et al.	
2010/0012704	A1	1/2010	Racenet et al.	
2010/0069942	A1	3/2010	Shelton, IV et al.	
2010/0072254	A1	3/2010	Aranyi et al.	
2010/0076429	A1	3/2010	Heinrich	
2010/0076459	A1	3/2010	Farascioni	
2010/0089970	A1	4/2010	Smith	
2010/0127041	A1	5/2010	Morgan et al.	
2010/0127042	A1	5/2010	Shelton, IV	
2010/0133317	A1	6/2010	Shelton, IV et al.	
2010/0133318	A1	6/2010	Boudreaux	
2010/0147921	A1	6/2010	Olson	
2010/0147922	A1	6/2010	Olson	
2010/0155453	A1	6/2010	Bombard et al.	
2010/0170931	A1	7/2010	Viola	
2010/0193566	A1	8/2010	Scheib et al.	
2010/0224668	A1	9/2010	Fontayne et al.	
2010/0230468	A1	9/2010	Viola	
2010/0237130	A1	9/2010	Scirica	
2010/0243709	A1	9/2010	Hess et al.	
2010/0249802	A1	9/2010	May et al.	
2010/0252611	A1	10/2010	Ezzat et al.	
2010/0252612	A1	10/2010	Viola	
2010/0264192	A1	10/2010	Marczyk	
2010/0264193	A1	10/2010	Huang et al.	
2010/0264194	A1	10/2010	Huang et al.	
2010/0294828	A1	11/2010	Bindra et al.	
2010/0294829	A1	11/2010	Giordano et al.	
2010/0301095	A1	12/2010	Shelton, IV et al.	
2010/0305552	A1	12/2010	Shelton, IV et al.	
2010/0308100	A1	12/2010	Boudreaux	
2010/0320252	A1	12/2010	Viola et al.	
2010/0320254	A1	12/2010	Zemlok et al.	
2011/0006099	A1	1/2011	Hall et al.	
2011/0006101	A1	1/2011	Hall et al.	
2011/0006103	A1	1/2011	Laurent et al.	
2011/0011914	A1	1/2011	Baxter, III et al.	
2011/0011915	A1	1/2011	Shelton, IV	
2011/0017801	A1	1/2011	Zemlok et al.	
2011/0024477	A1	2/2011	Hall	
2011/0024478	A1	2/2011	Shelton, IV	
2011/0036887	A1	2/2011	Zemlok et al.	
2011/0036888	A1	2/2011	Pribanic et al.	
2011/0036890	A1	2/2011	Ma	
2011/0036891	A1	2/2011	Zemlok et al.	
2011/0036892	A1	2/2011	Marczyk et al.	
2011/0036895	A1	2/2011	Marczyk et al.	
2011/0042439	A1	2/2011	Johnson et al.	
2011/0042441	A1	2/2011	Shelton, IV et al.	
2011/0062213	A1	3/2011	Scirica et al.	
2011/0068145	A1	3/2011	Bedi et al.	
2011/0068148	A1	3/2011	Hall et al.	
2011/0084114	A1	4/2011	Marczyk et al.	
2011/0084115	A1	4/2011	Bedi et al.	
2011/0087276	A1	4/2011	Bedi et al.	
2011/0089221	A1	4/2011	Masiakos et al.	
2011/0095067	A1	4/2011	Ohdaira	
2011/0101067	A1	5/2011	Johnson et al.	
2011/0101069	A1	5/2011	Bombard et al.	
2011/0108603	A1	5/2011	Racenet et al.	
2011/0114702	A1	5/2011	Farascioni	
2011/0121049	A1	5/2011	Malinouskas et al.	
2011/0132961	A1	6/2011	Whitman et al.	
2011/0132963	A1	6/2011	Giordano et al.	
2011/0132964	A1	6/2011	Weisenburgh, II et al.	
2011/0132965	A1	6/2011	Moore et al.	
2011/0139851	A1	6/2011	McCuen	
2011/0144640	A1	6/2011	Heinrich et al.	
2011/0147433	A1	6/2011	Shelton, IV et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0147434	A1	6/2011	Hueil et al.
2011/0155781	A1	6/2011	Swensgard et al.
2011/0155784	A1	6/2011	Shelton, IV et al.
2011/0155786	A1	6/2011	Shelton, IV
2011/0155787	A1	6/2011	Baxter, III et al.
2011/0155788	A1	6/2011	Hillstead et al.
2011/0163146	A1	7/2011	Ortiz et al.
2011/0163147	A1	7/2011	Laurent et al.
2011/0163149	A1	7/2011	Viola
2011/0163150	A1	7/2011	Farascioni
2011/0168757	A1	7/2011	Viola et al.
2011/0168760	A1	7/2011	Viola et al.
2011/0174862	A1	7/2011	Shelton, IV et al.
2011/0174863	A1	7/2011	Shelton, IV et al.
2011/0180585	A1	7/2011	Czernik et al.
2011/0186614	A1	8/2011	Kasvikis
2011/0192881	A1	8/2011	Balbierz et al.
2011/0192882	A1	8/2011	Hess et al.
2011/0192883	A1	8/2011	Whitman et al.
2011/0198385	A1	8/2011	Whitman et al.
2011/0198386	A1	8/2011	Viola
2011/0204119	A1	8/2011	McCuen
2011/0204120	A1	8/2011	Crainich
2011/0210157	A1	9/2011	Knodel et al.
2011/0215132	A1	9/2011	Aranyi et al.
2011/0215133	A1	9/2011	Aranyi
2011/0226837	A1	9/2011	Baxter, III et al.
2011/0233258	A1	9/2011	Boudreaux
2011/0233259	A1	9/2011	Olson
2011/0240713	A1	10/2011	Scirica et al.
2011/0240714	A1	10/2011	Whitman et al.
2011/0253765	A1	10/2011	Nicholas et al.
2011/0257679	A1	10/2011	Ishitsuki et al.

FOREIGN PATENT DOCUMENTS

DE	2903159	1/1980
DE	3114135	10/1982
DE	4213426	10/1992
DE	4300307	7/1994
EP	0041022	12/1981
EP	0136950	4/1985
EP	0140552	5/1985
EP	0156774	10/1985
EP	0216532	4/1987
EP	0220029	4/1987
EP	0213817	11/1987
EP	0273468	7/1988
EP	0324166	7/1989
EP	0324635	7/1989
EP	0324637	7/1989
EP	0324638	7/1989
EP	0369324	5/1990
EP	0373762	6/1990
EP	0380025	8/1990
EP	0399701	11/1990
EP	0449394	10/1991
EP	0484677	5/1992
EP	0489436	6/1992
EP	0503662	9/1992
EP	0514139	11/1992
EP	0536903	4/1993
EP	0537572	4/1993
EP	0539762	5/1993
EP	0545029	6/1993
EP	0552050	7/1993
EP	0552423	7/1993
EP	0579038	1/1994
EP	0589306	3/1994
EP	0591946	4/1994
EP	0592243	4/1994
EP	0592244	4/1994
EP	0593920	4/1994
EP	0598202	5/1994
EP	0598579	5/1994
EP	0600182	6/1994
EP	0621006	10/1994
EP	0621009	10/1994
EP	0656188	6/1995
EP	0365153	8/1995
EP	0666057	8/1995
EP	0674876	10/1995
EP	0699418	3/1996
EP	0 705 570 A1	4/1996
EP	0705571	4/1996
EP	0760230	3/1997
EP	0 807 409	11/1997
FR	2542188	9/1984
FR	2660851	10/1991
FR	2681775	10/1991
GB	1352554	4/1971
GB	1452185	10/1976
GB	1555455	11/1979
GB	2048685	12/1980
GB	2070499	9/1981
GB	2141066	12/1984
GB	2165559	4/1986
JP	51-149985	6/1975
SU	659146	4/1979
SU	728848	5/1980
SU	980703	12/1982
SU	990220	1/1983
WO	WO 8302247	7/1983
WO	WO 89/10094	11/1989
WO	WO 9210976	7/1992
WO	WO 9308754	5/1993
WO	WO 9314706	8/1993

OTHER PUBLICATIONS

EP Search Report EP 90167613.0-2320 date of completion Mar. 11, 2010.
European Search Report EP 08252877 dated Jun. 23, 2009.
European Search Report EP 09167613.0 dated Mar. 17, 2010.
European Search Report EP 09175507.4 dated Jan. 20, 2010.
European Search Report EP 10175047.9 dated Nov. 25, 2010.
European Search Report EP 10175056.0 dated Jul. 10.2012.
European Search Report EP 10185767.0 dated Mar. 3. 2011.

* cited by examiner

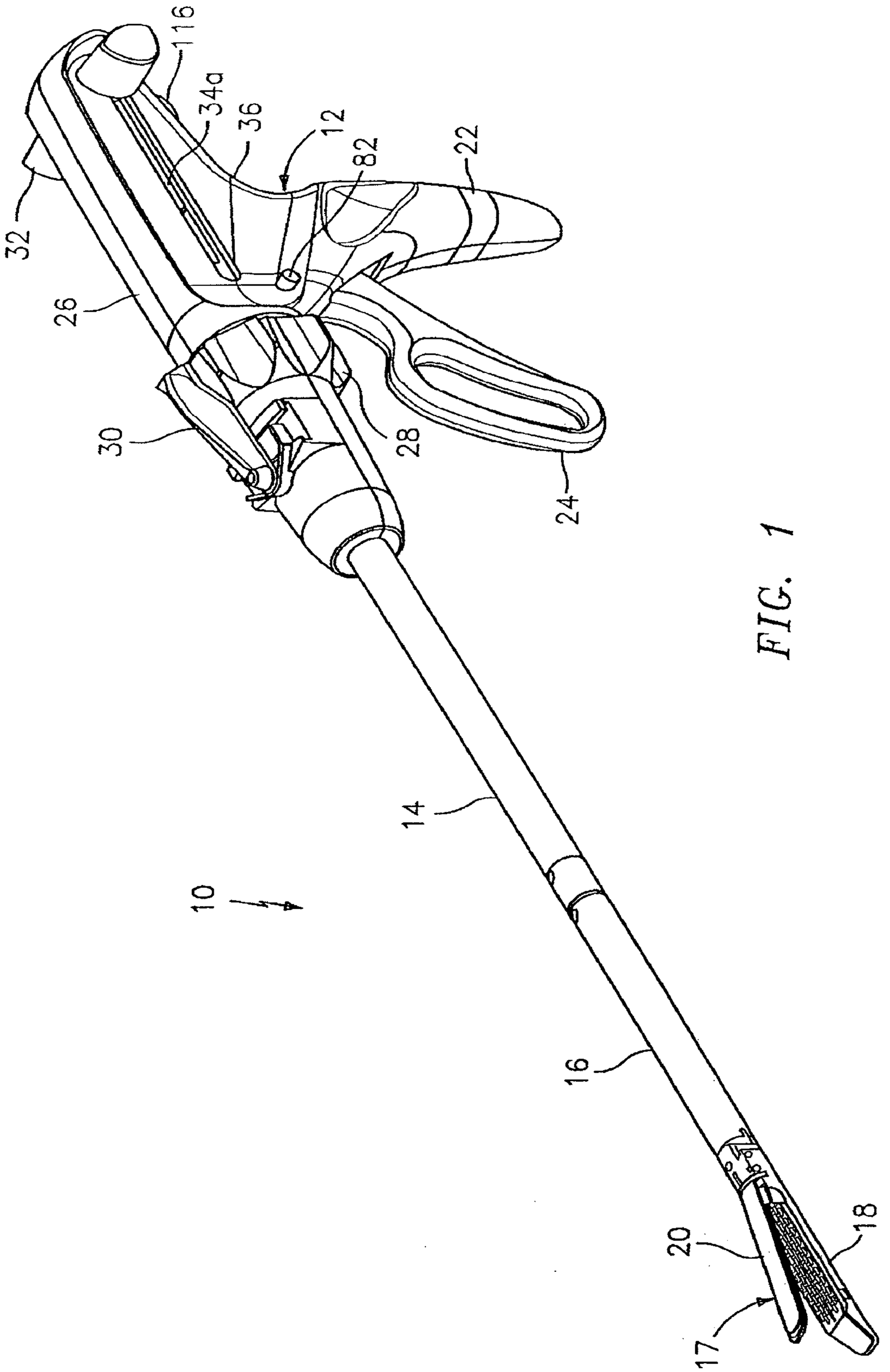


FIG. 1

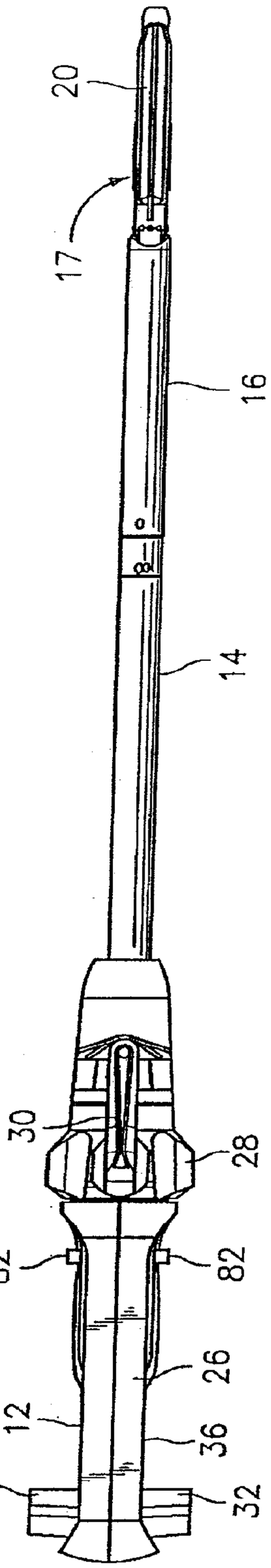

20
17
16
14
30
28
82
82
26
12
36
32
32

FIG. 2

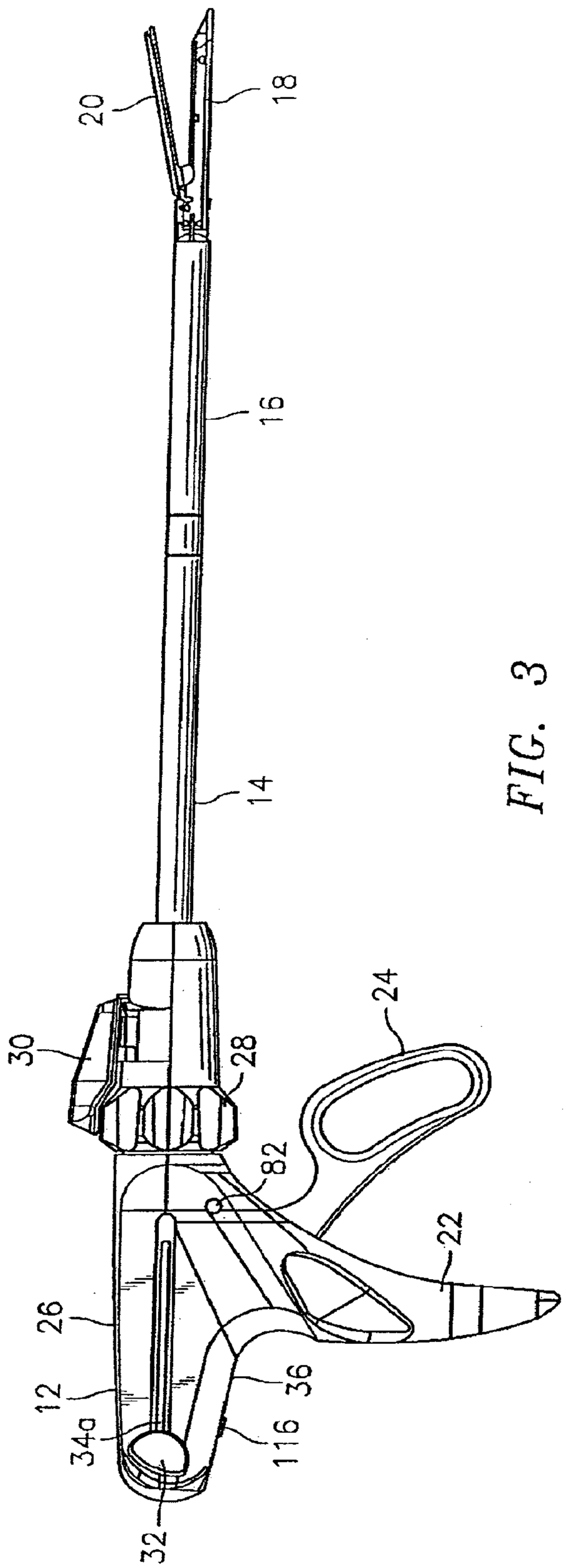

20
18
16
14
30
28
24
82
22
26
12
36
34a
116
32

FIG. 3

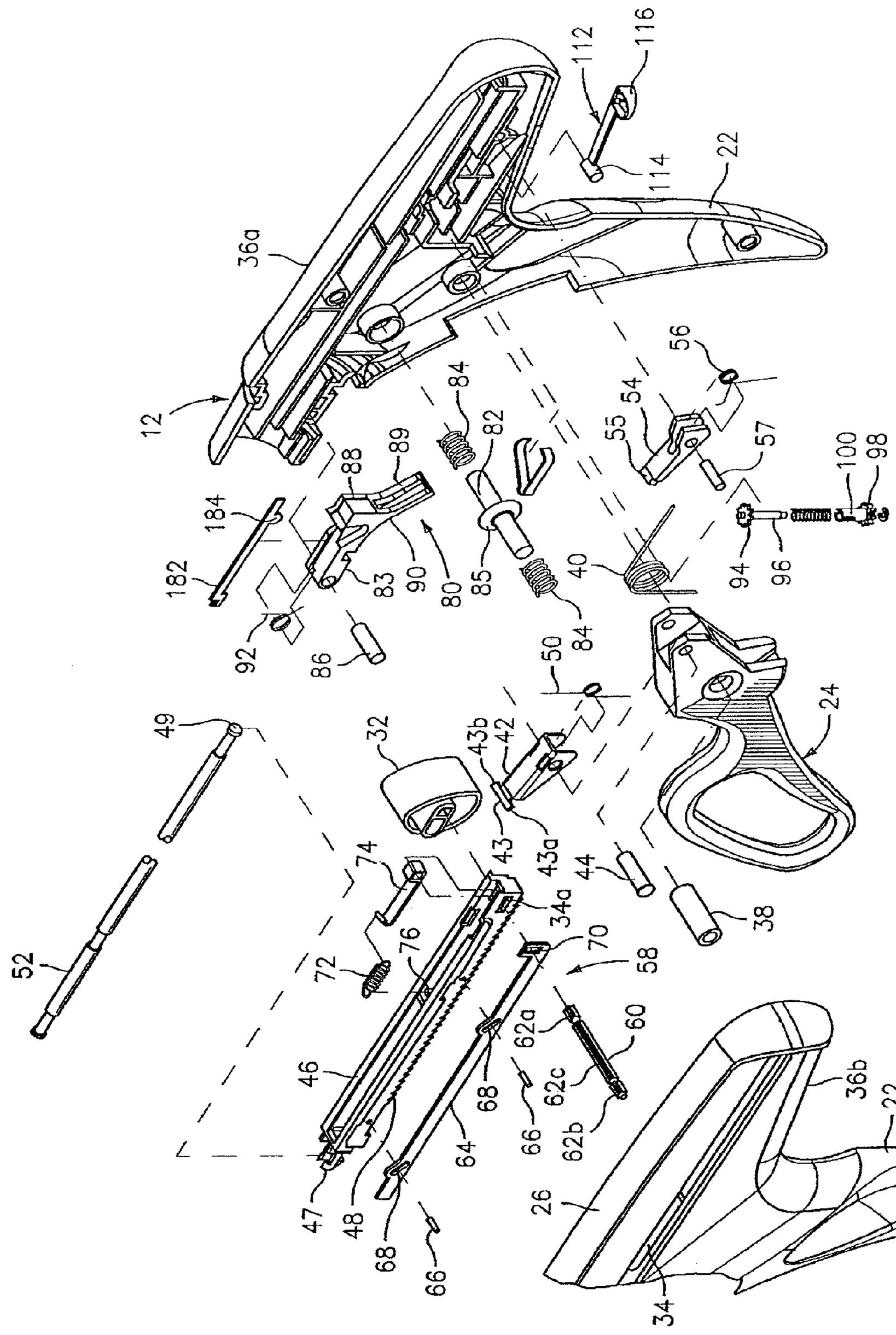

12
112
116
114
22
36a
84
82
88
89
184
182
83
90
80
85
92
86
56
54
55
57
100
98
94
96
40
50
84
24
49
32
43b
42
43
43a
74
34a
44
38
52
72
76
70
58
62a
60
62c
62b
66
68
64
46
47
48
68
66
36b
22
26
34

FIG. 4

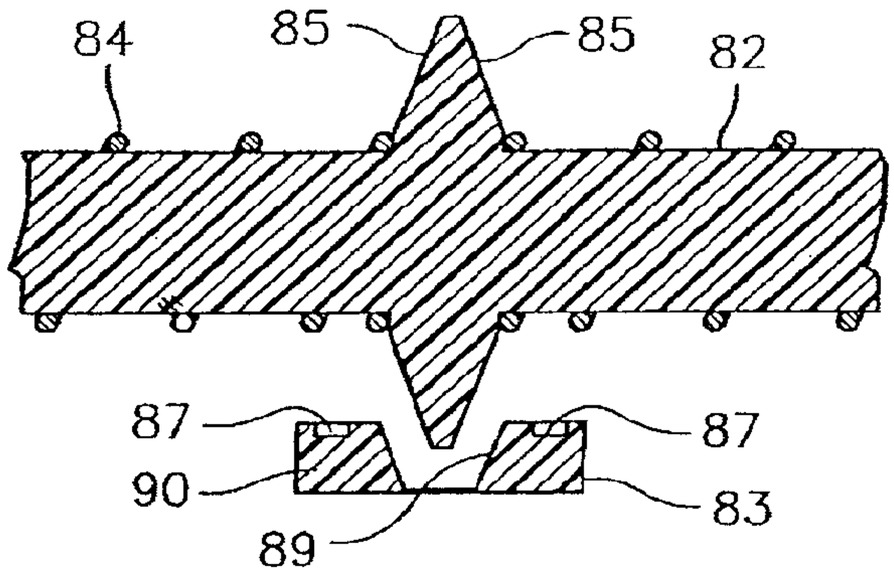


FIG. 5

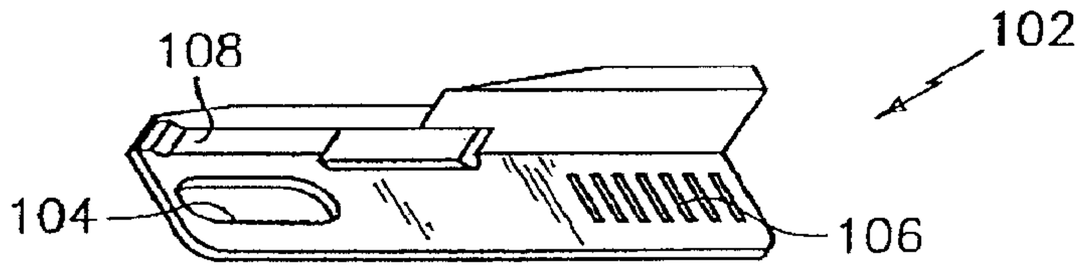


FIG. 6

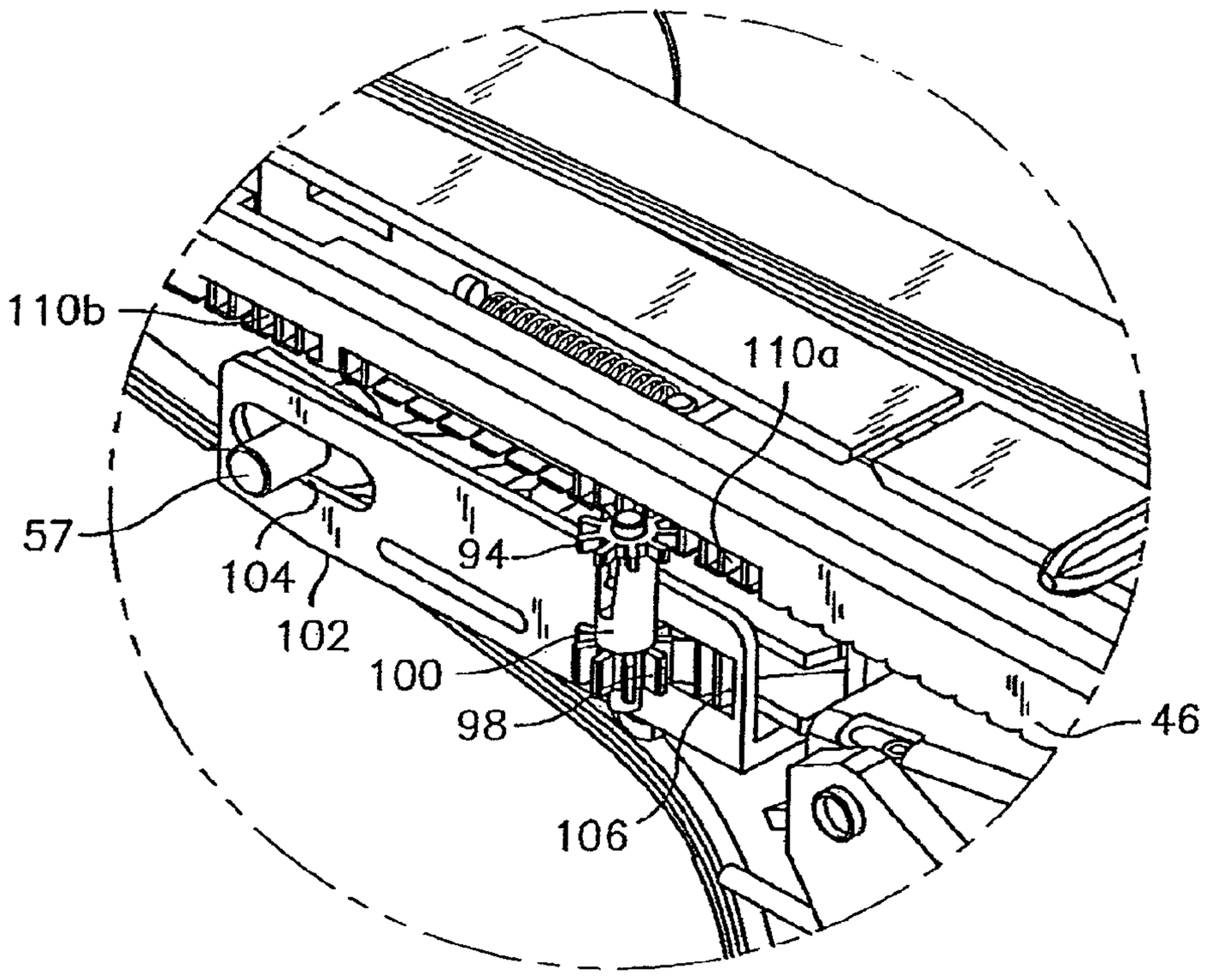


FIG. 7

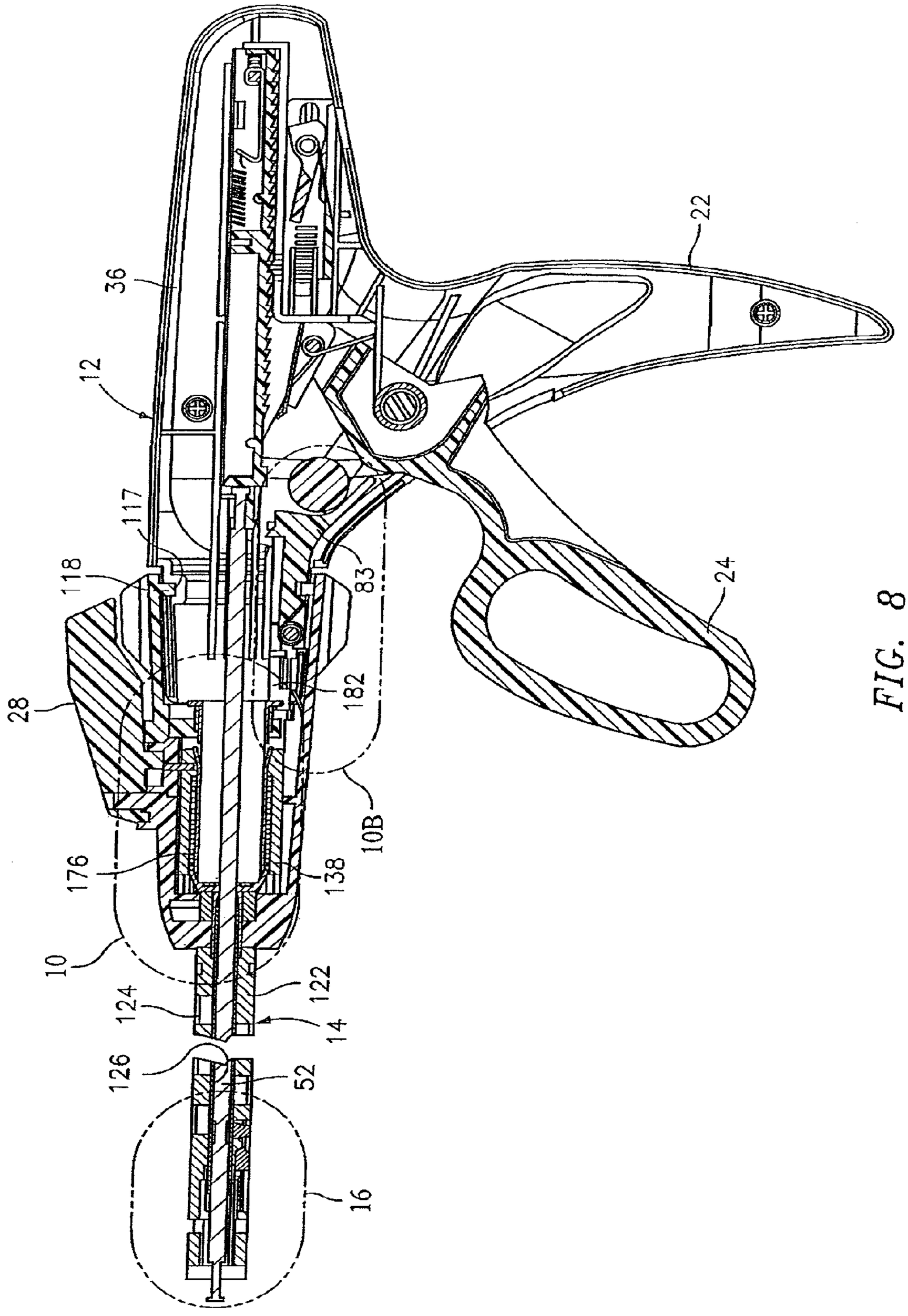


FIG. 8

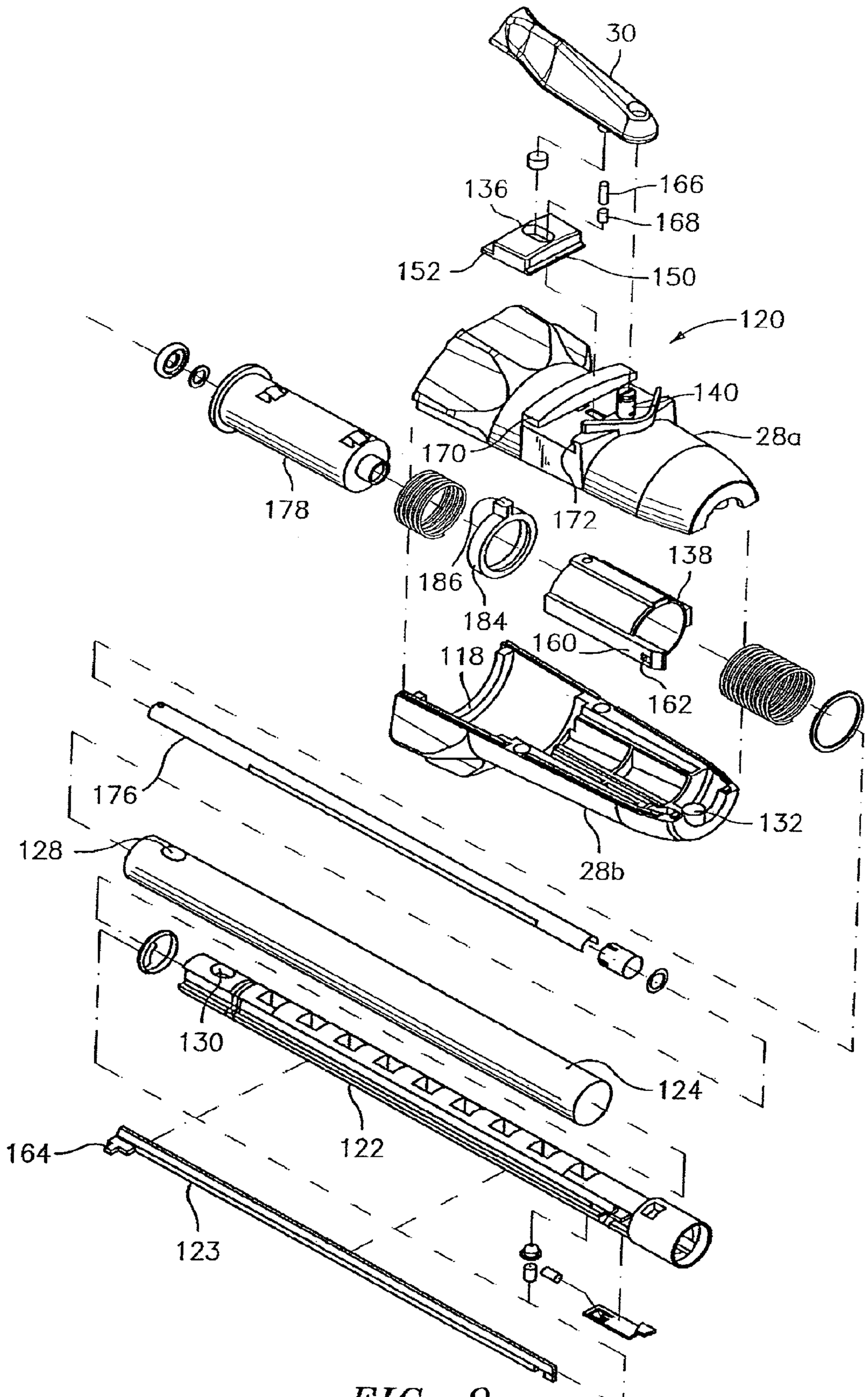

30
136
166
168
152
150
120
140
28a
170
178
172
138
186
184
160
118
162
176
132
28b
128
130
124
122
164
123

FIG. 9

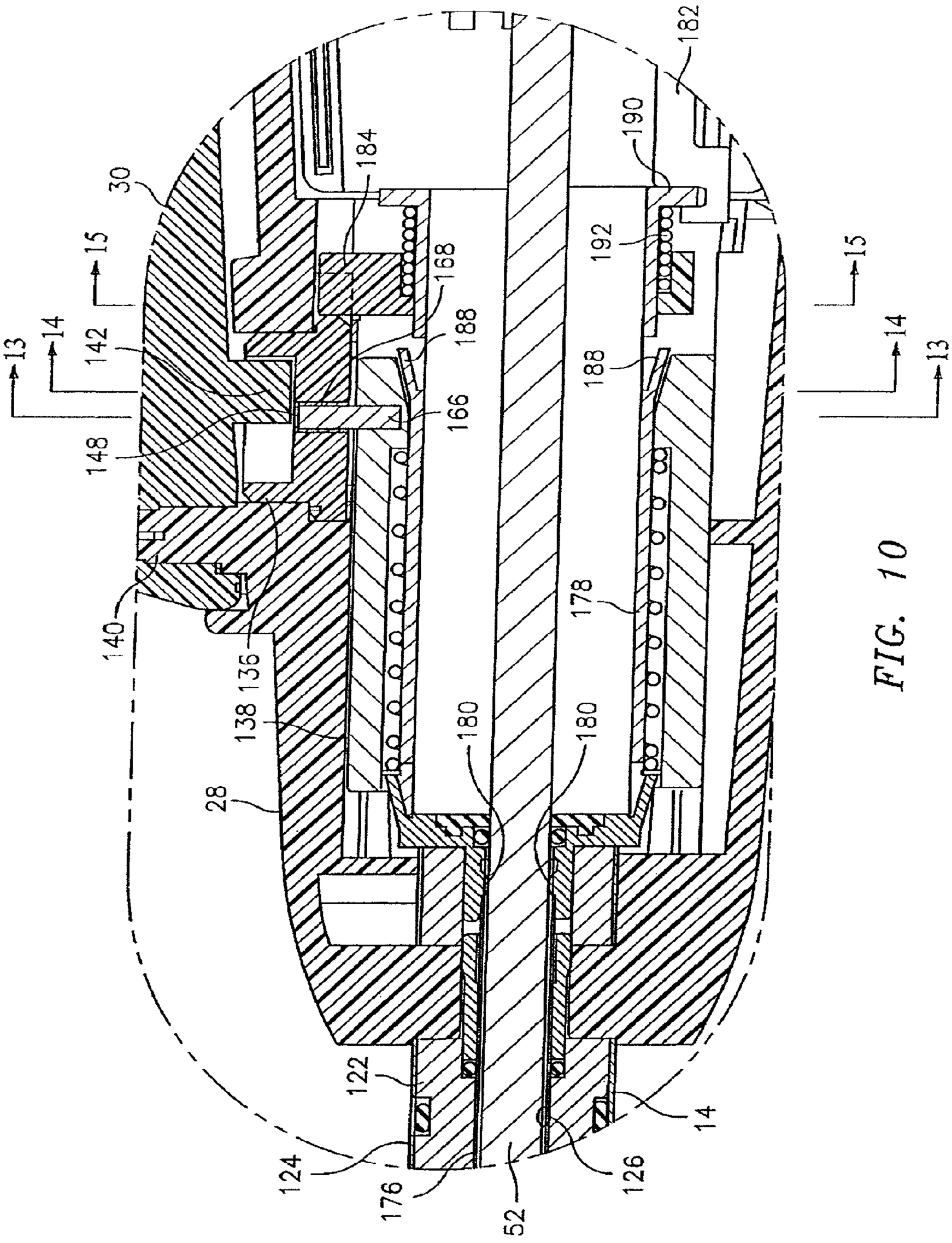

182
184
190
30
15
168
192
188
142
13
14
166
148
140
178
136
138
180
28
122
124
176
52
126

FIG. 10

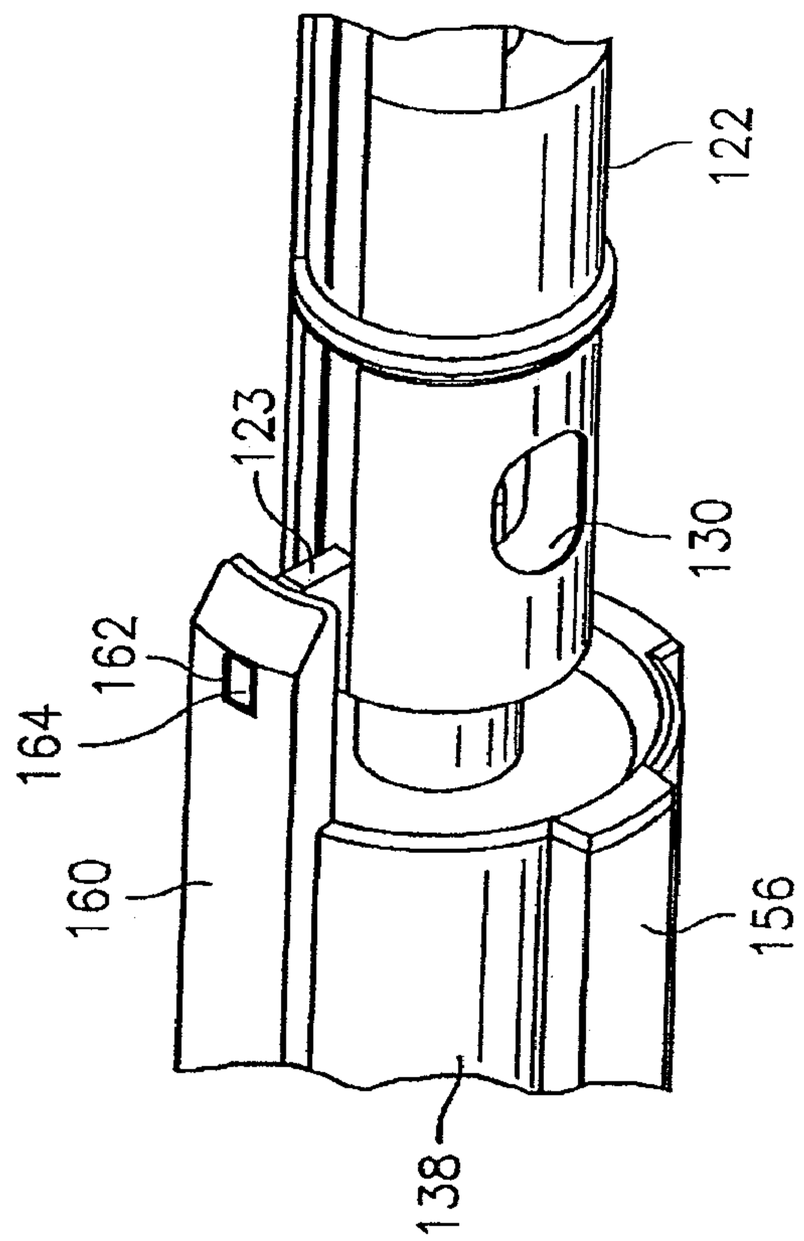


FIG. 10A

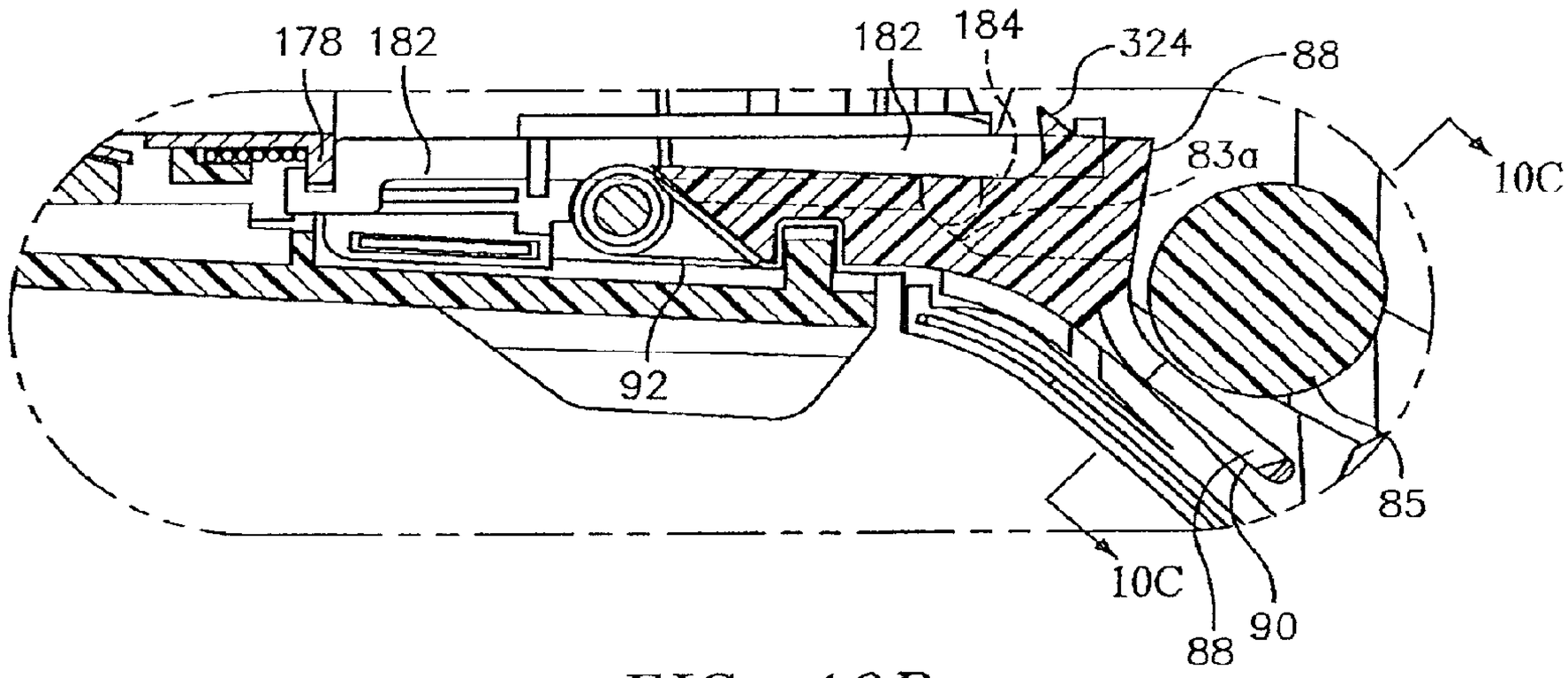


FIG. 10B

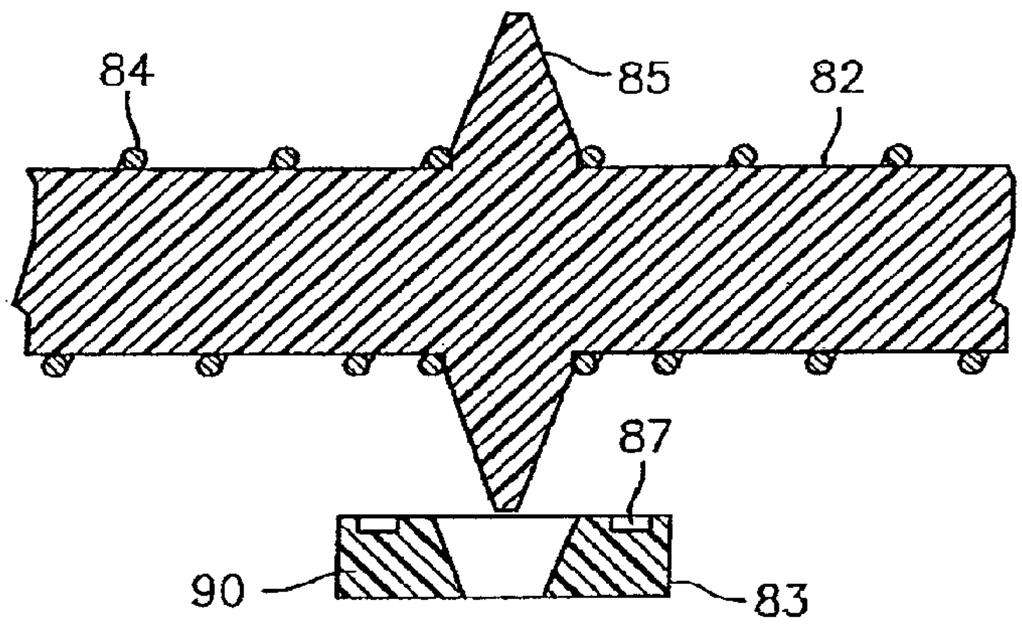


FIG. 10C

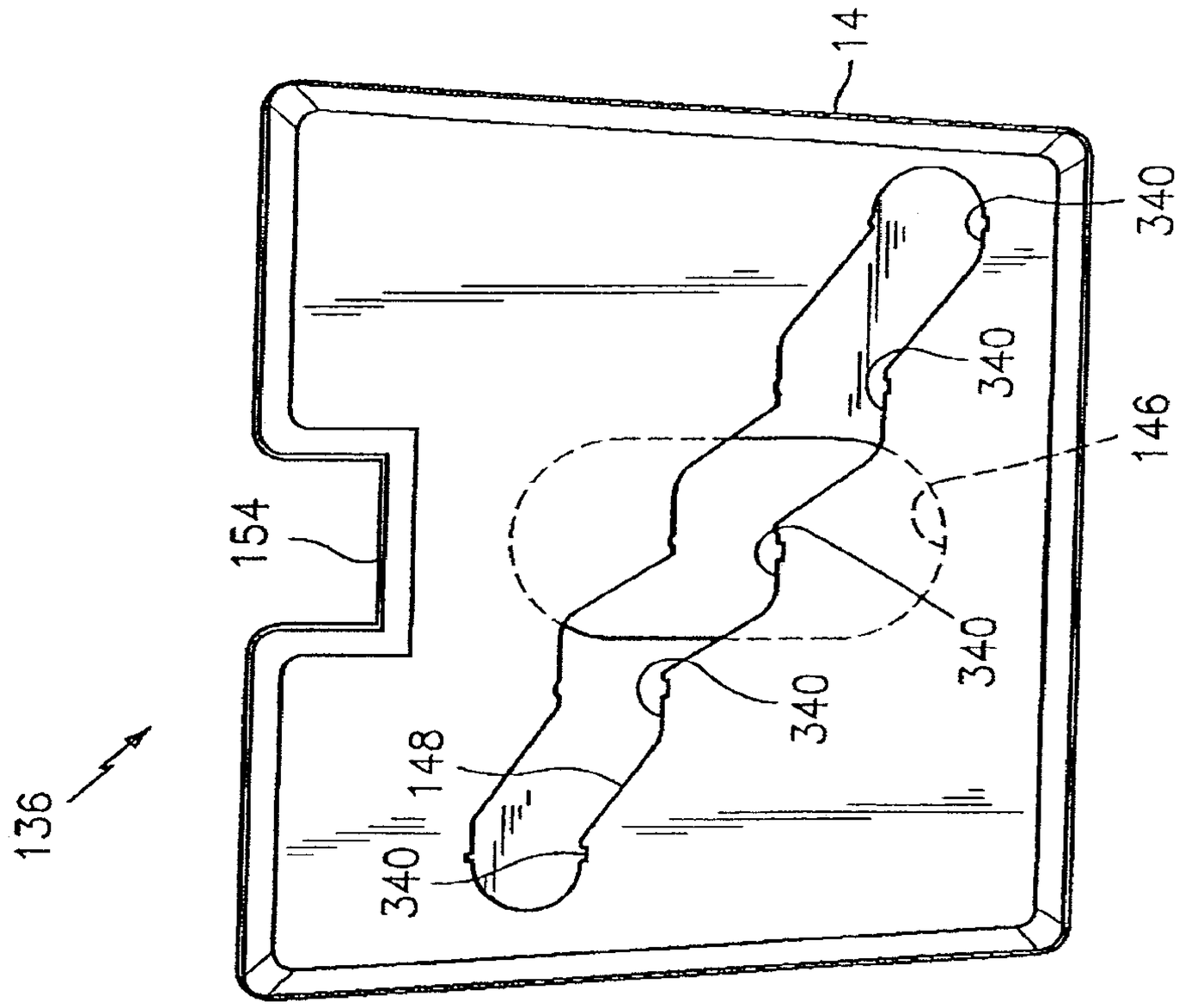


FIG. 12

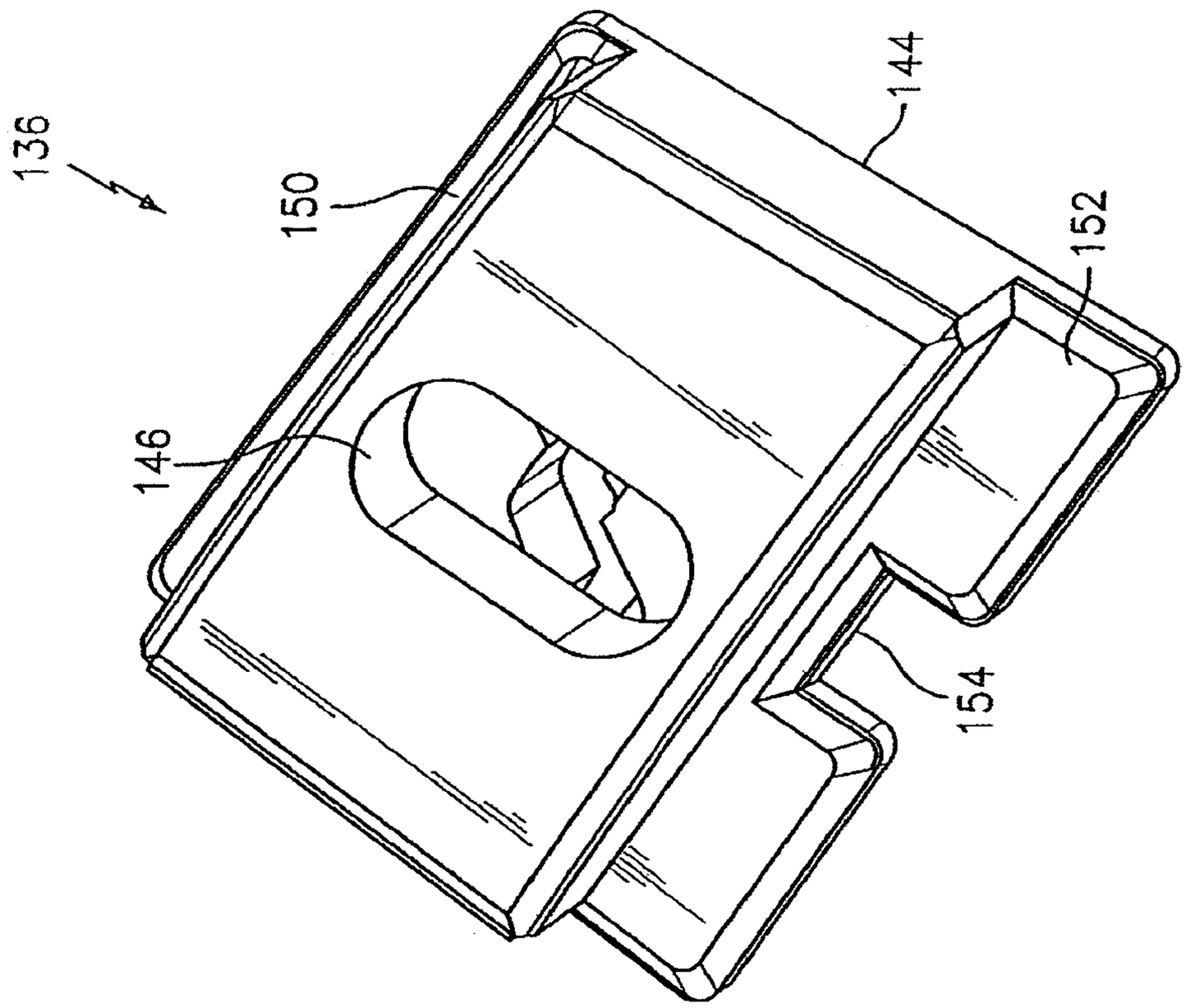


FIG. 11

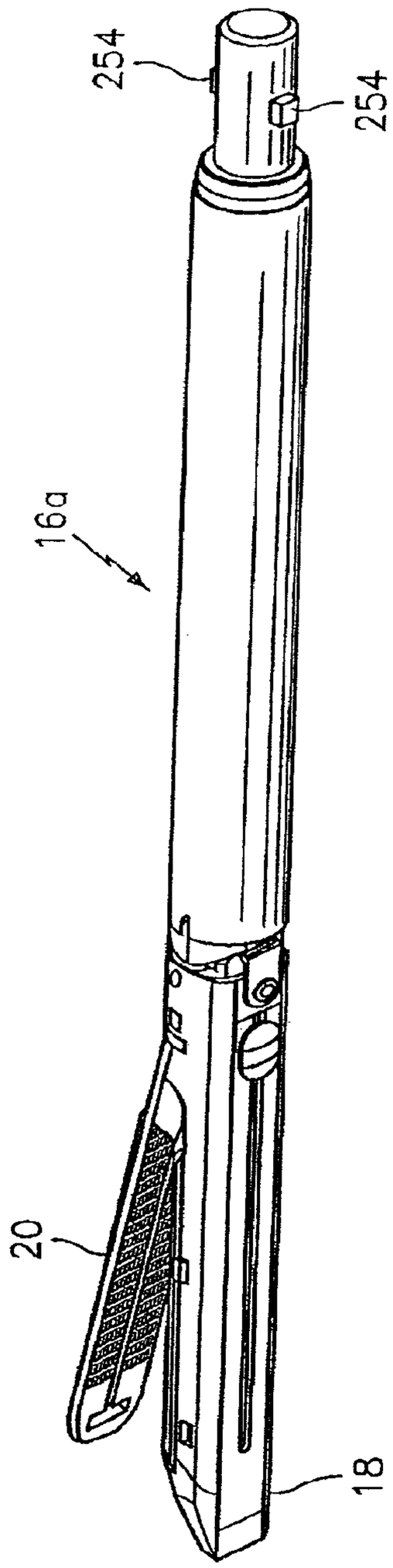


FIG. 12A

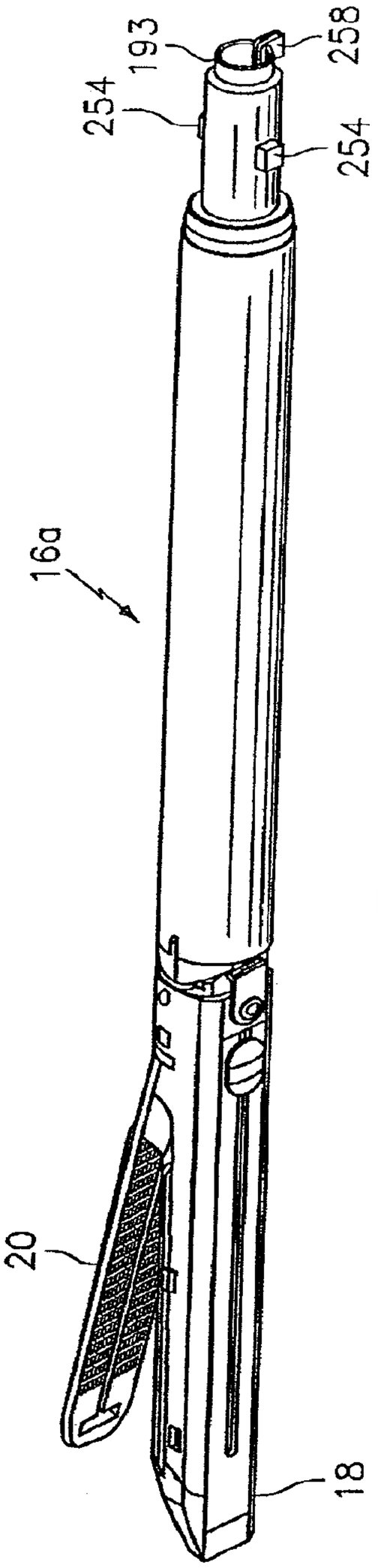


FIG. 12B

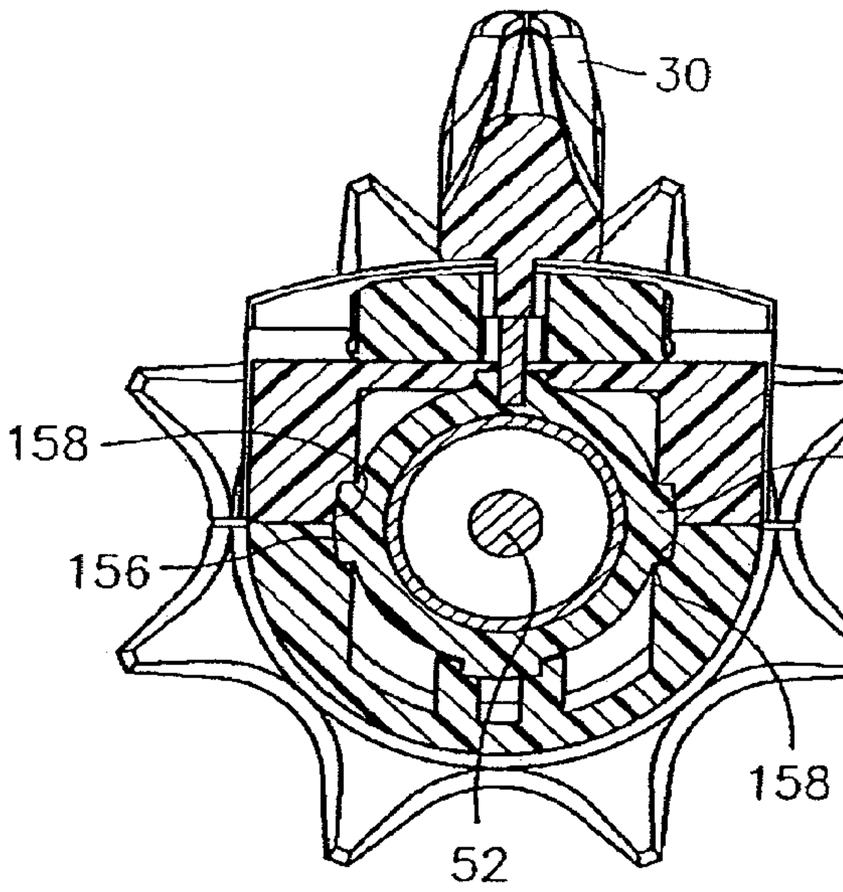


FIG. 13

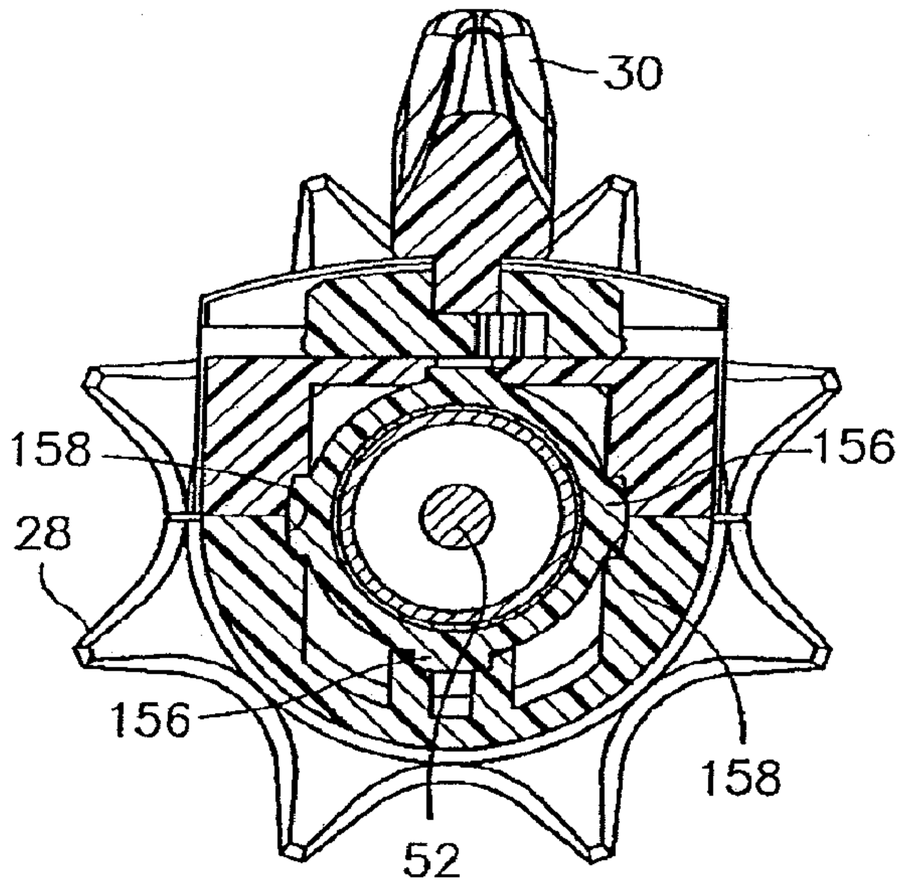


FIG. 14

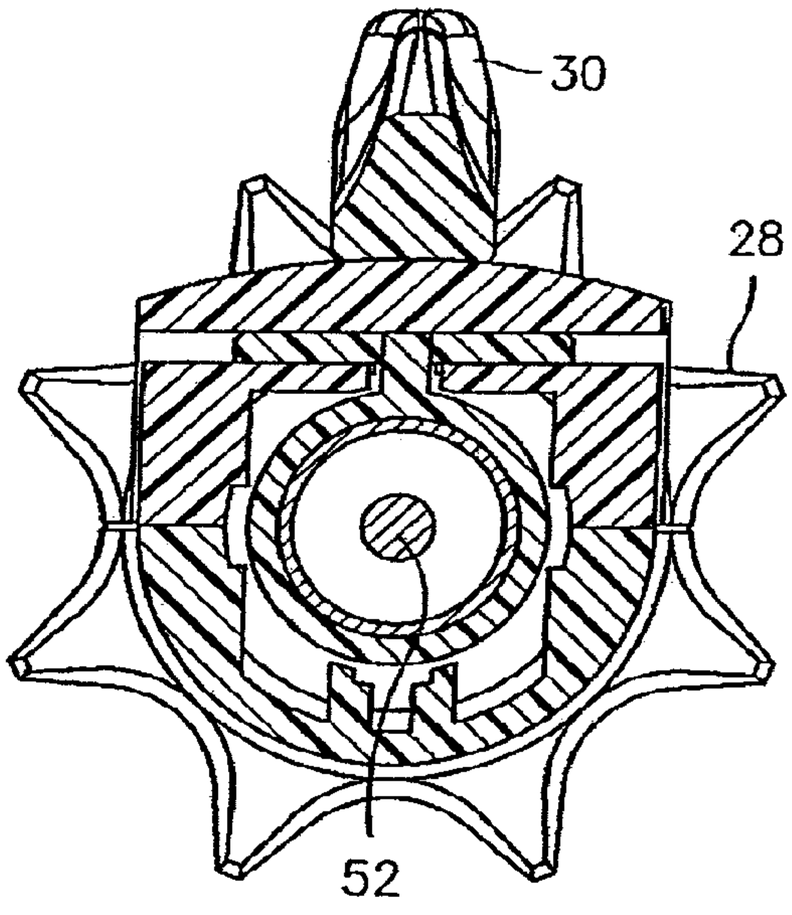


FIG. 15

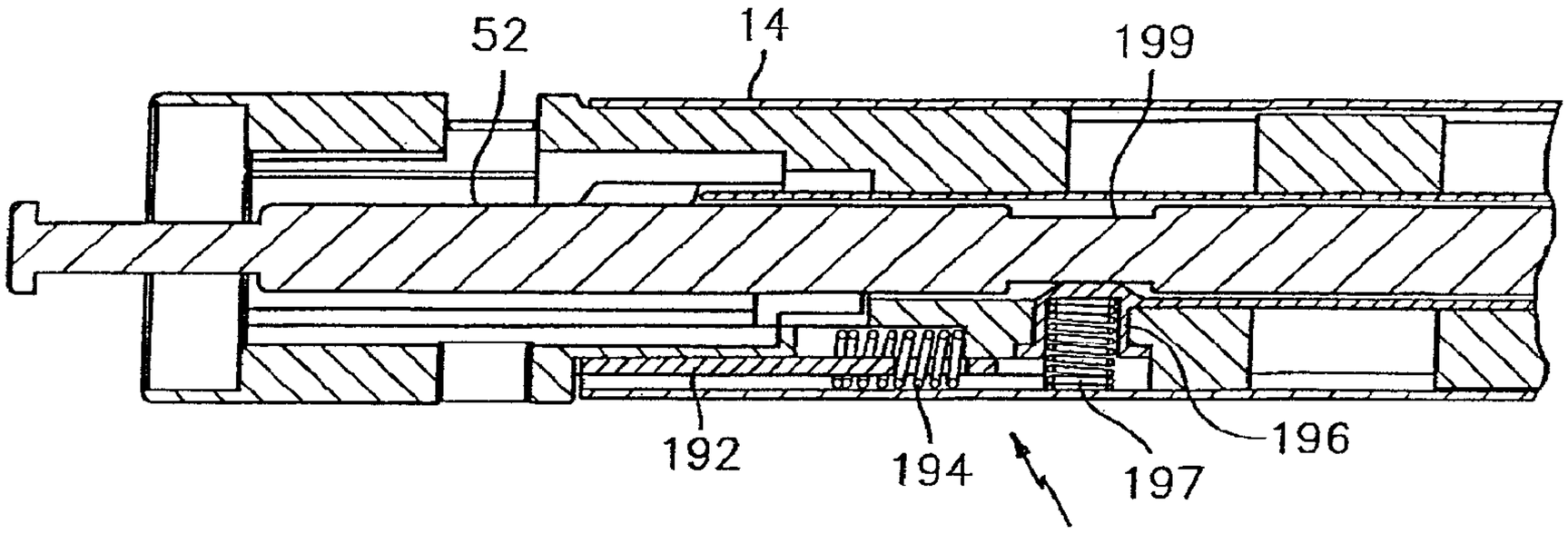


FIG. 16

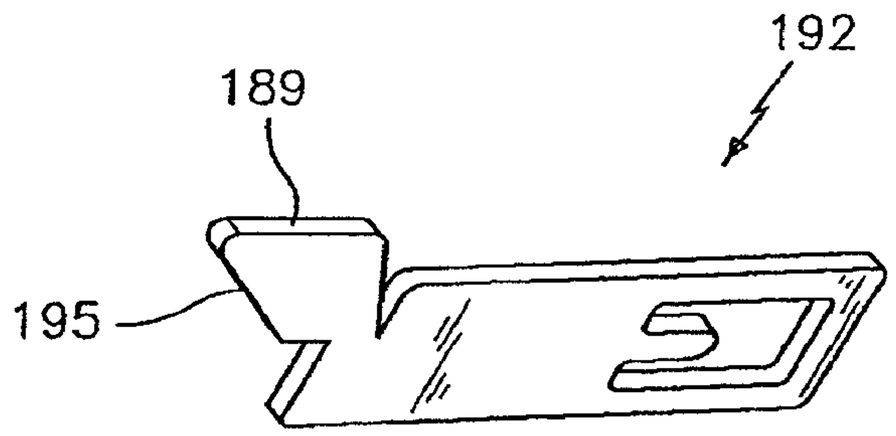


FIG. 17

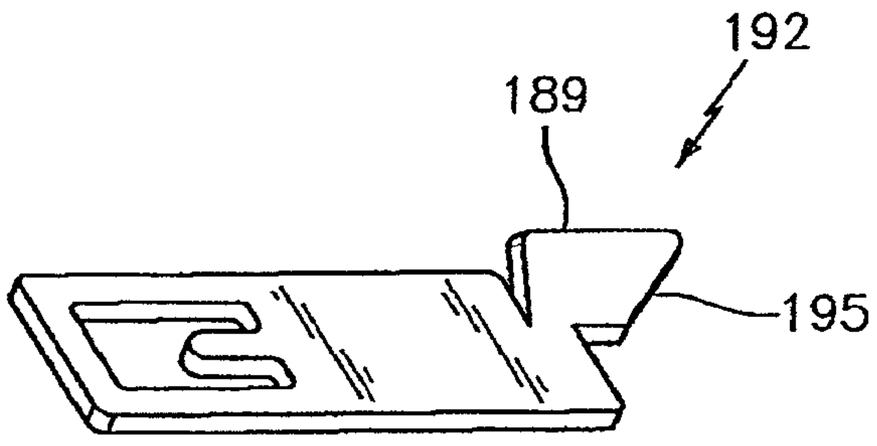


FIG. 18

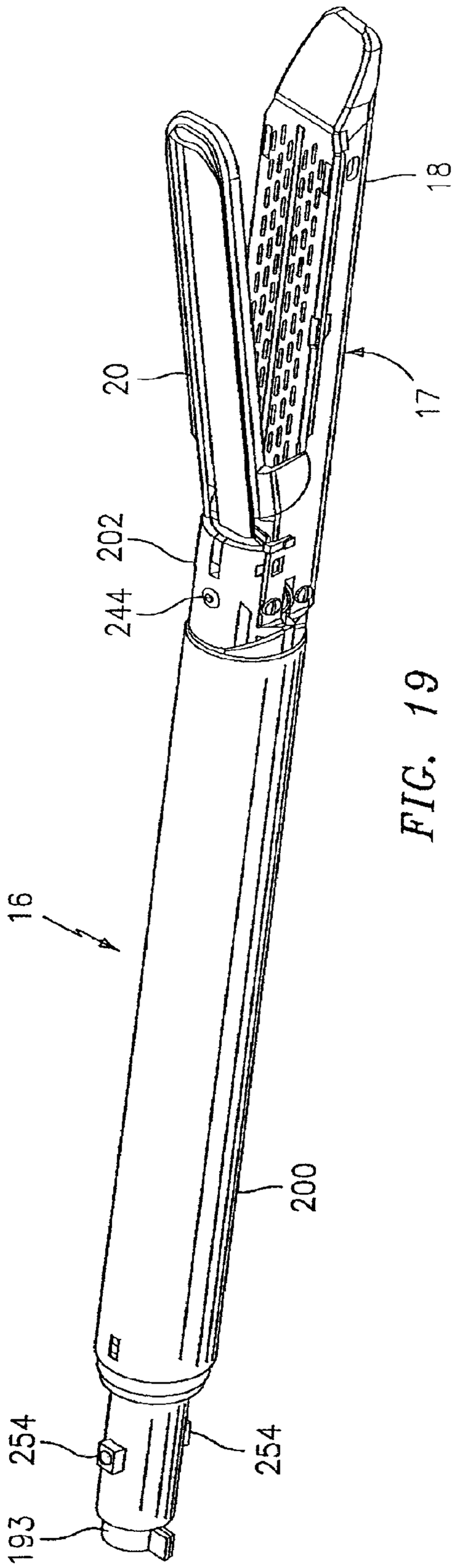

18
20
17
202
244
16
200
254
254
193

FIG. 19

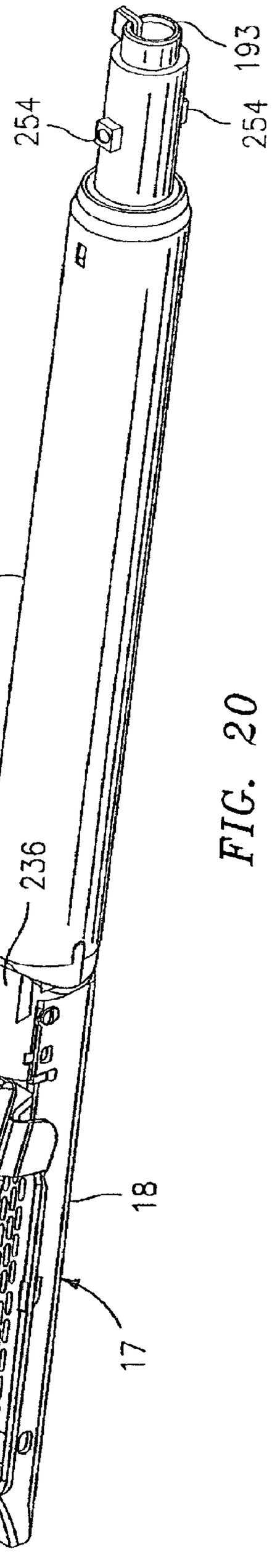

193
254
254
200
236
244
202
18
20
17

FIG. 20

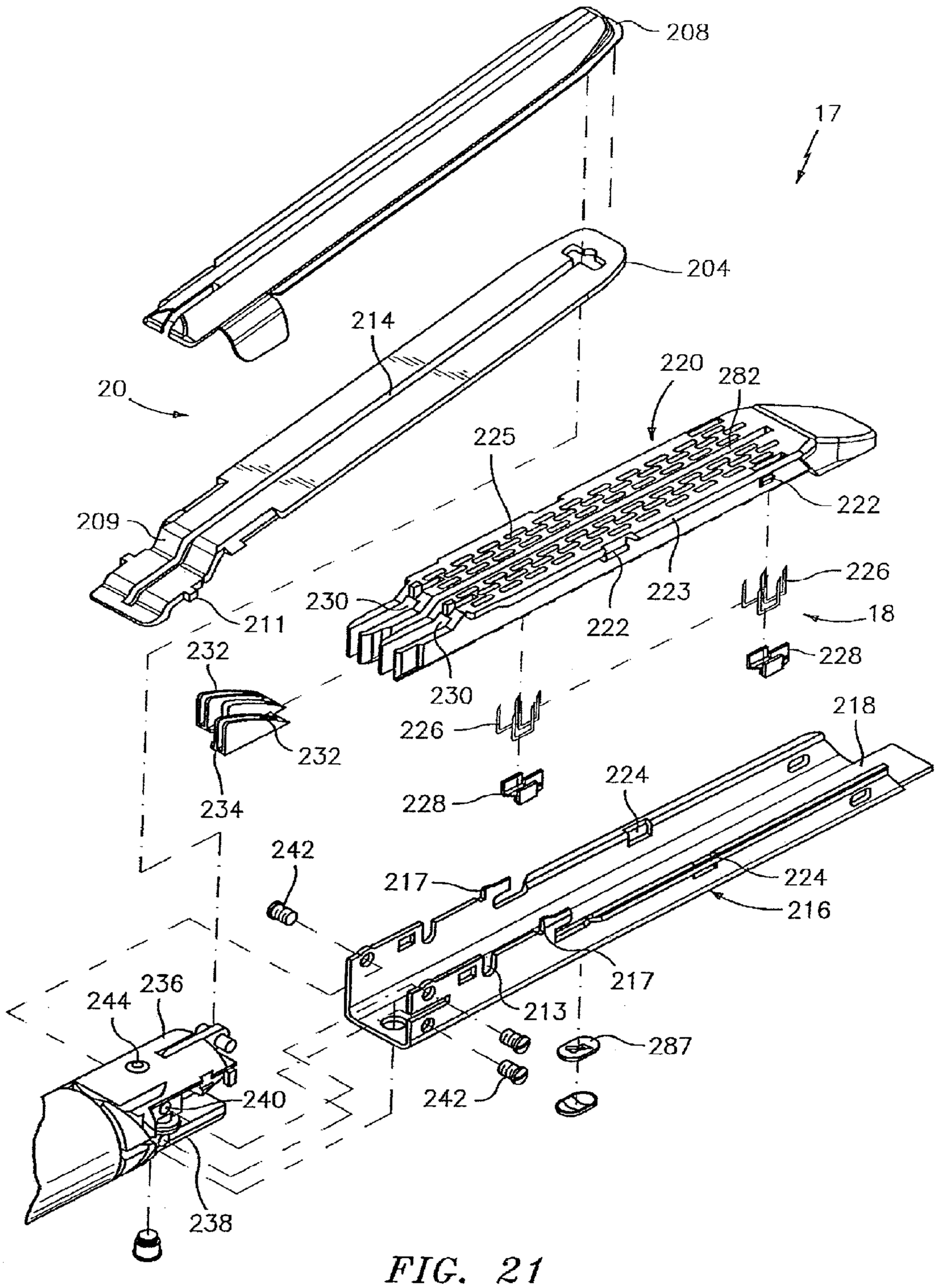

208
17
204
214
20
220
282
225
209
222
223
226
230
18
211
222
228
232
230
226
218
232
224
234
228
242
217
224
216
213
217
287
244
236
240
242
238

FIG. 21

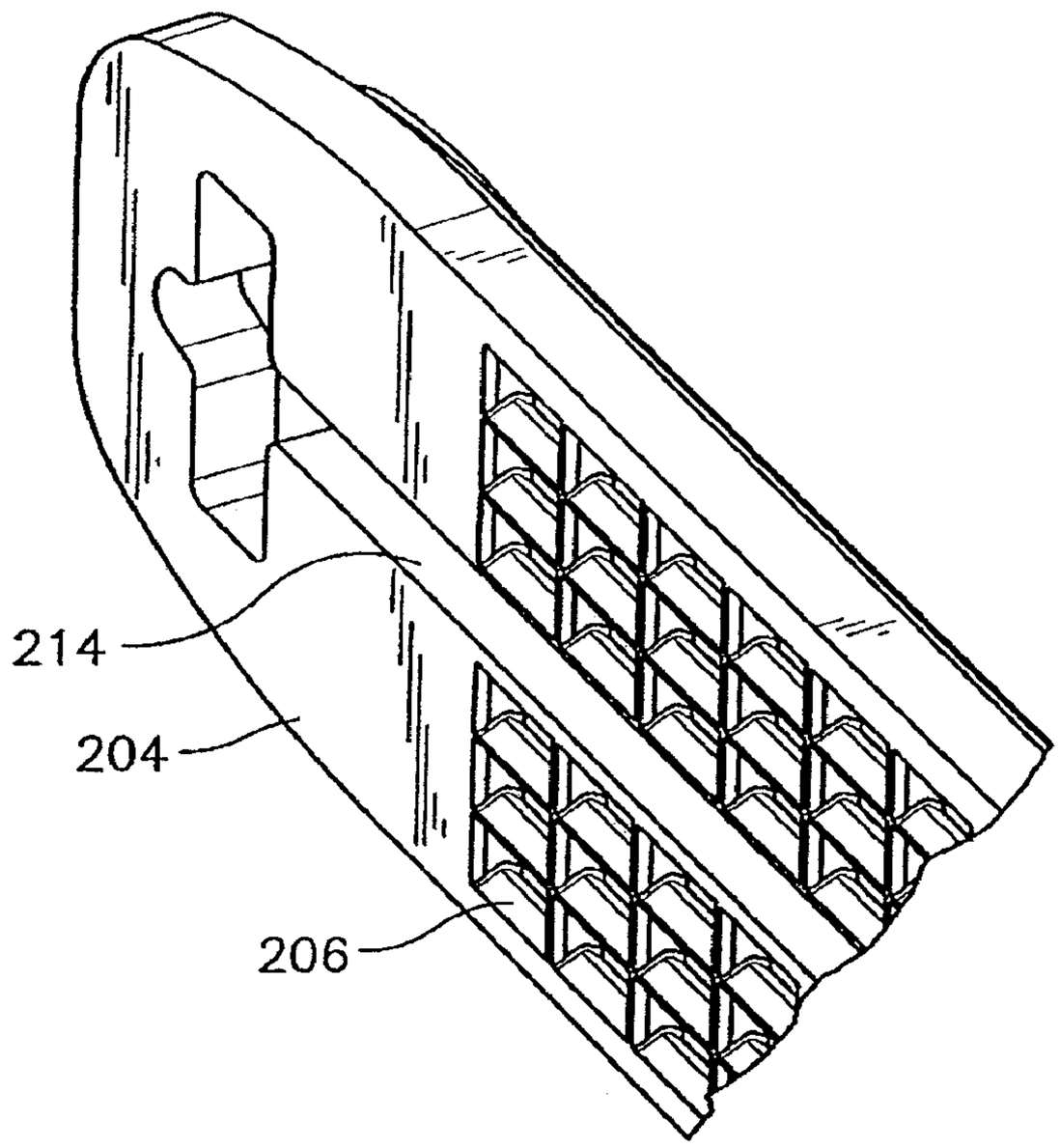


FIG. 22

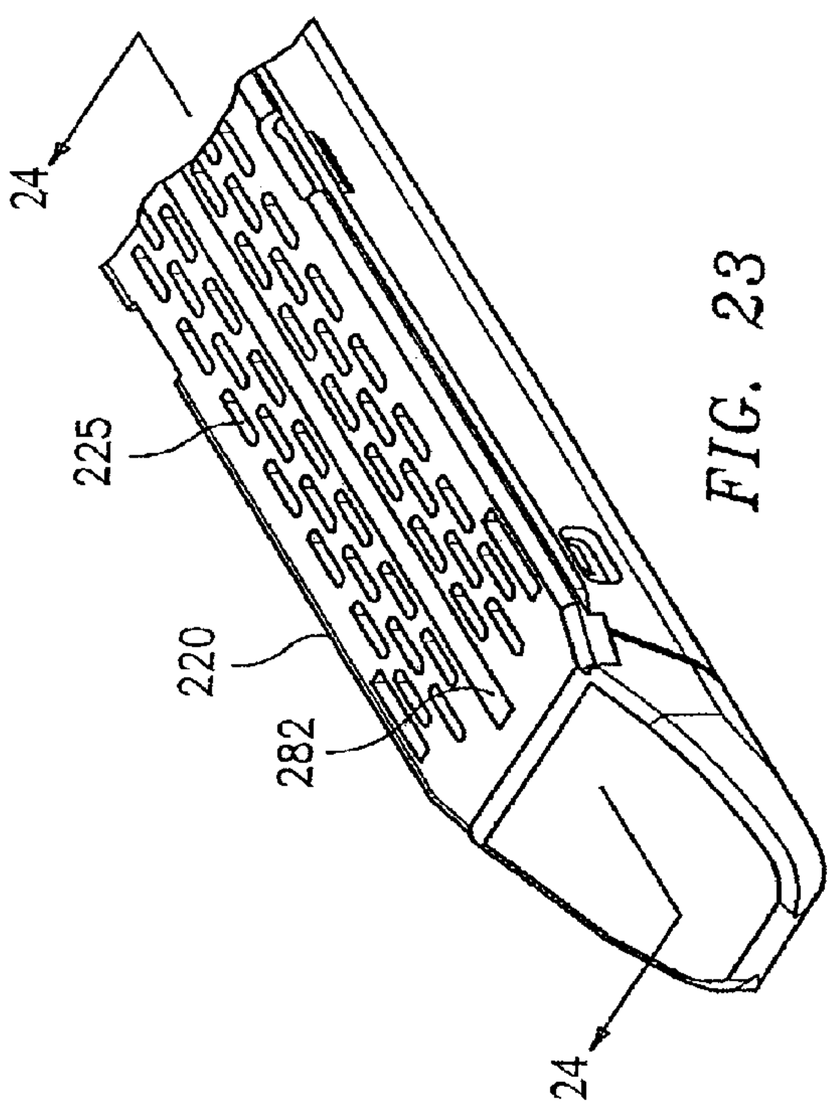

24
225
220
282
24

FIG. 23

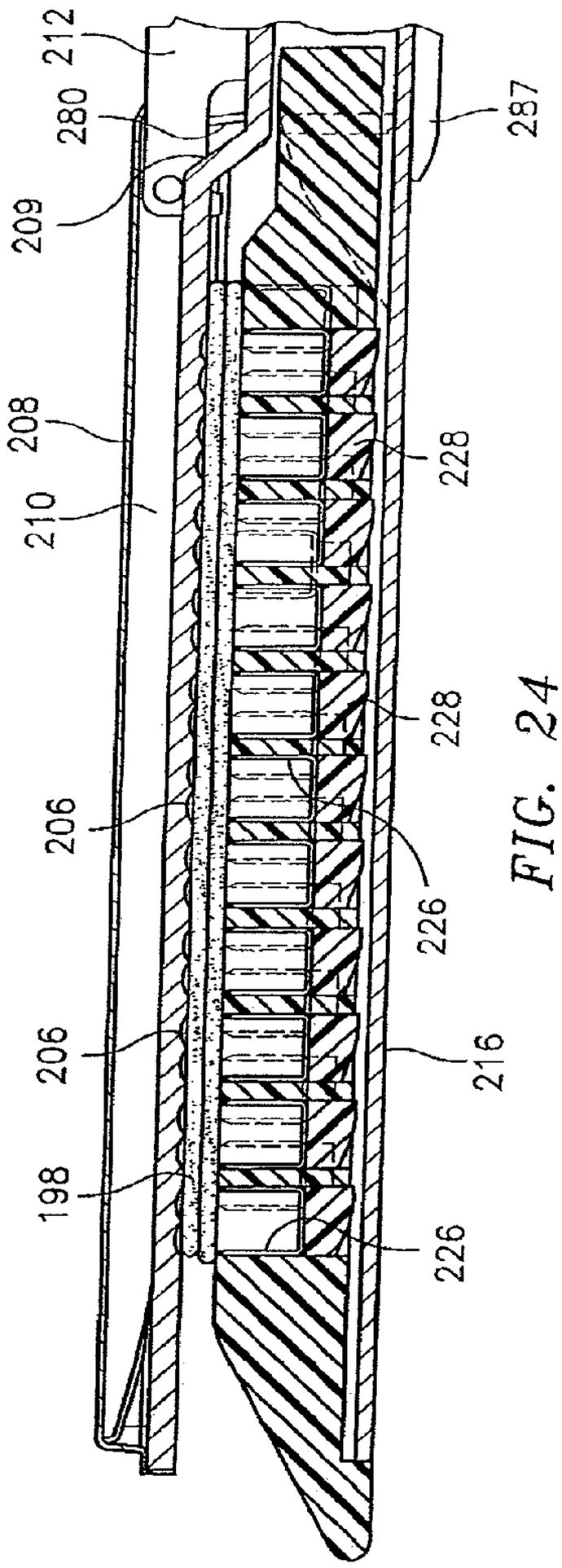

212
280
209
287
208
210
228
206
228
206
226
206
216
198
226

FIG. 24

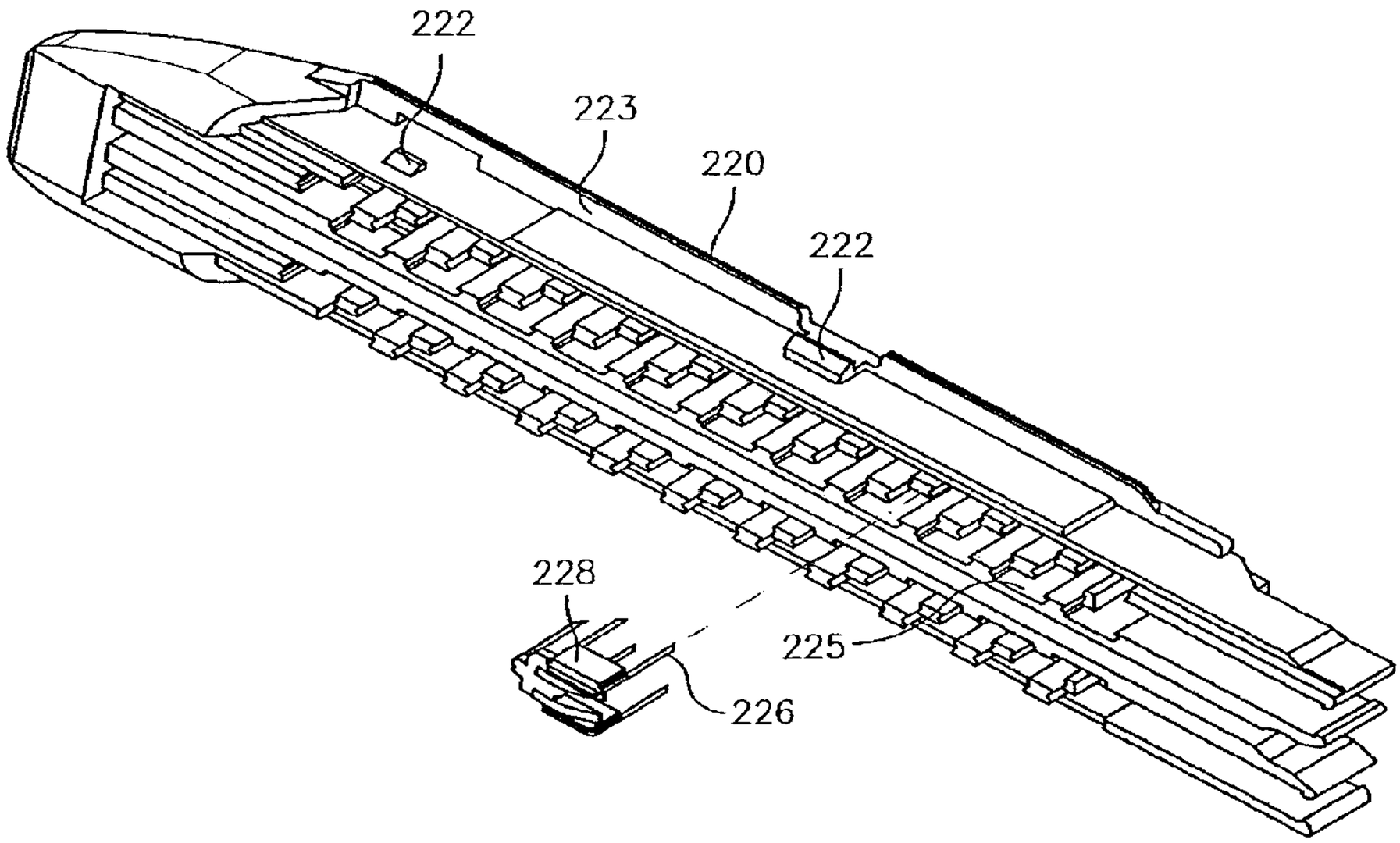


FIG. 25

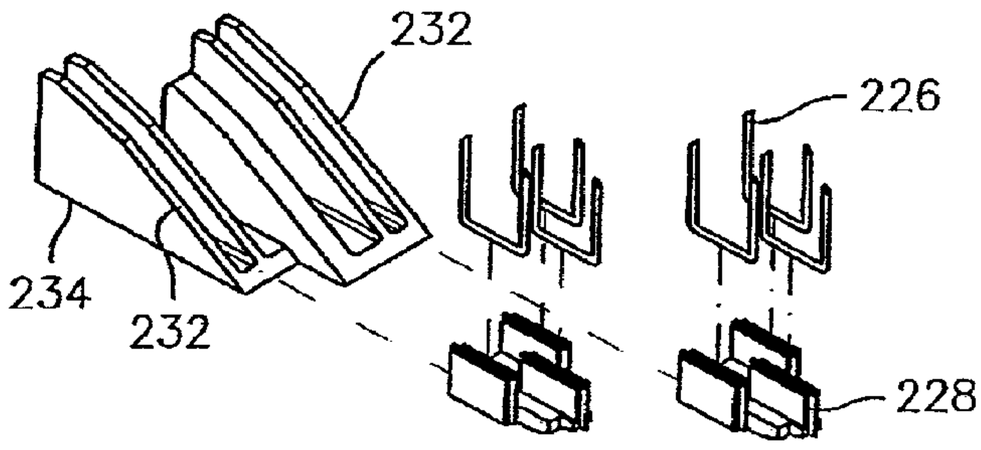


FIG. 26

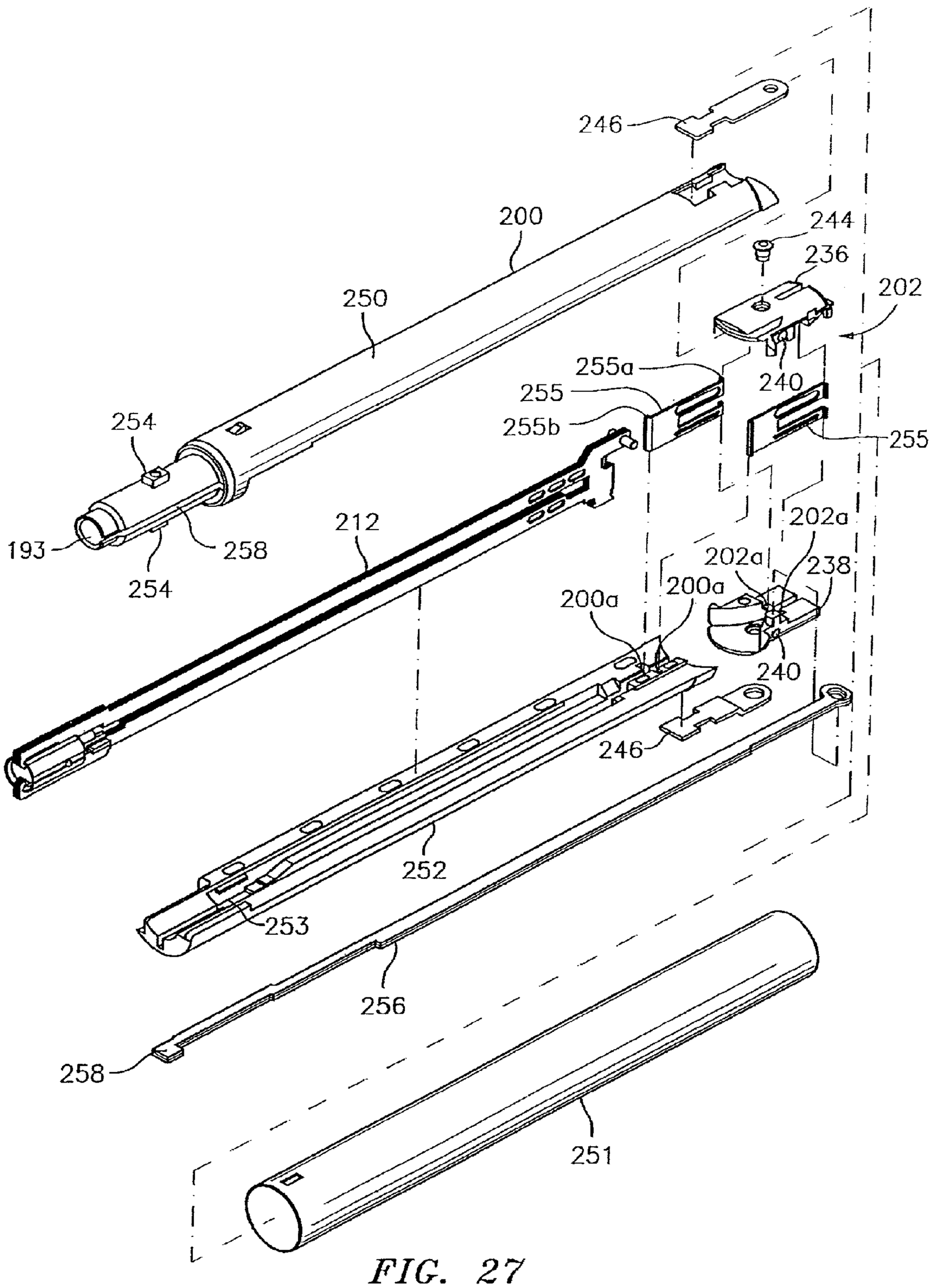

246
200
244
236
202
250
255a
255
240
255b
254
255
193
258
212
202a
254
202a
238
200a
200a
240
246
252
253
256
258
251

FIG. 27

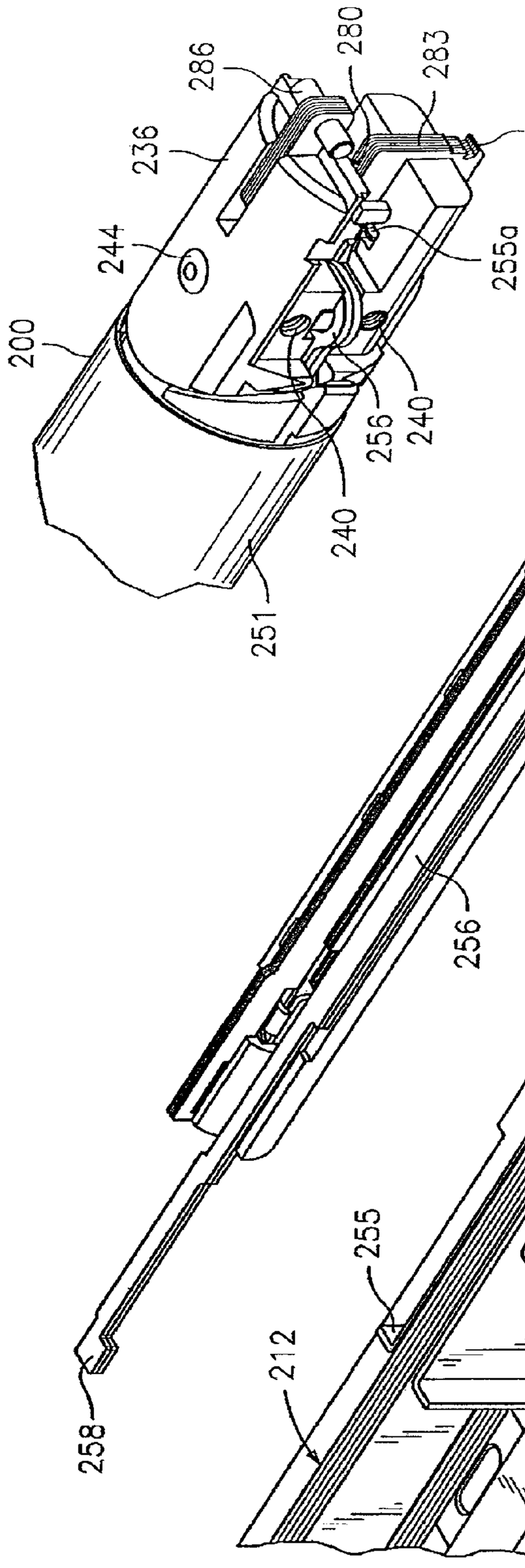


FIG. 28

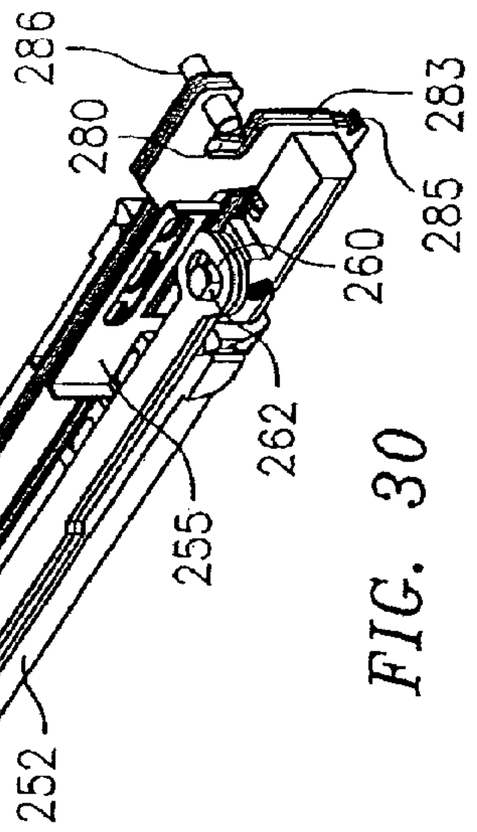


FIG. 30

FIG. 29

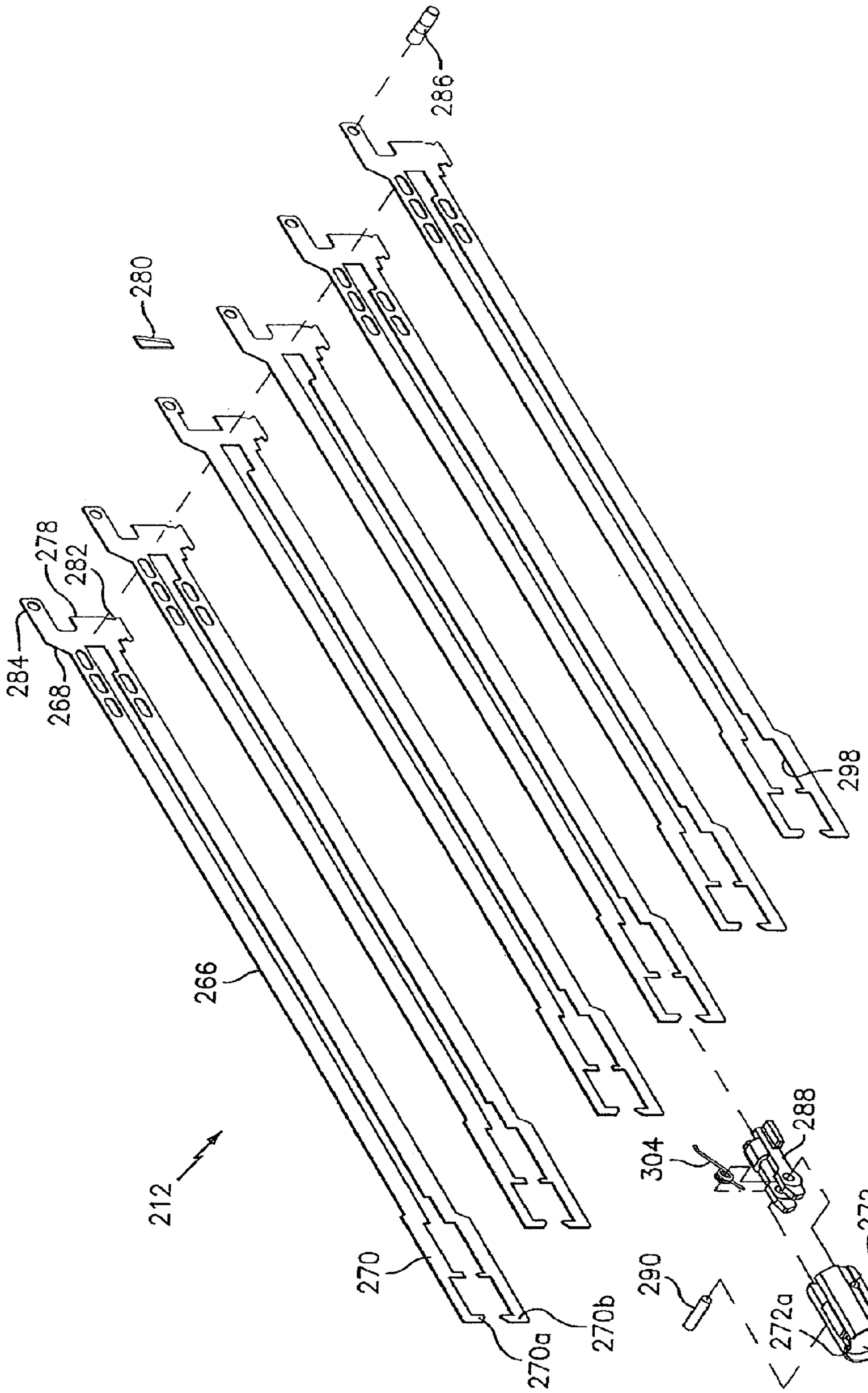

286
280
278
282
284
268
266
270
270a
270b
212
298
304
288
290
272
272b
272a
274

FIG. 31

FIG. 32

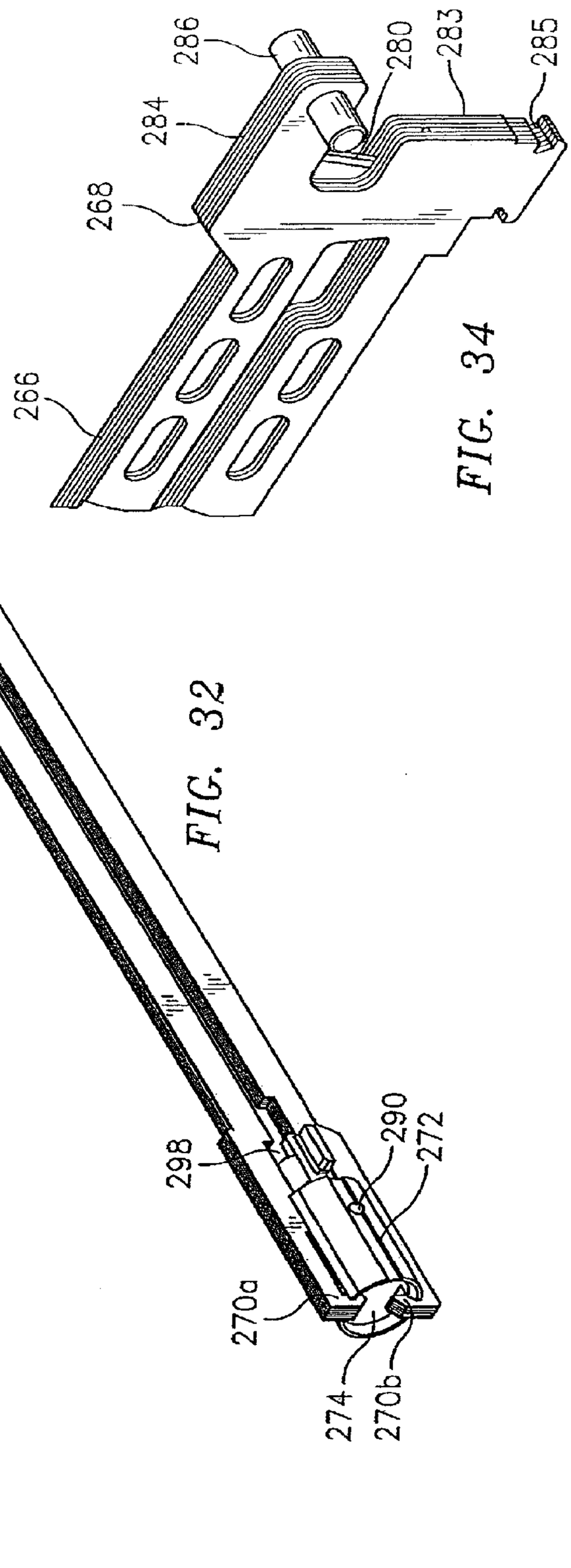


FIG. 33

FIG. 34

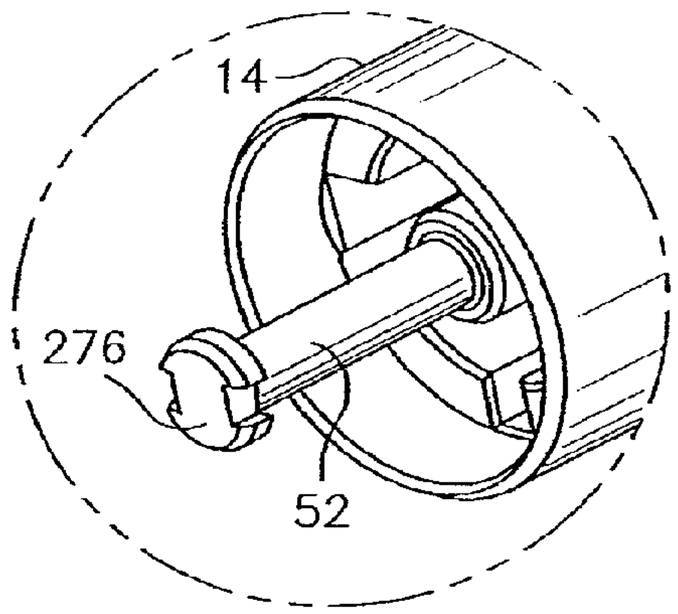


FIG. 35

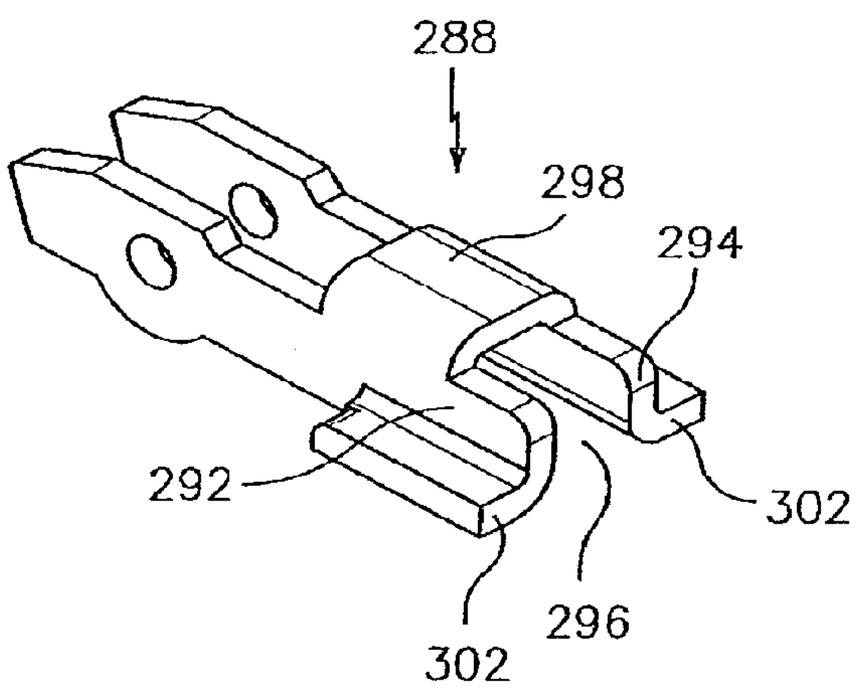


FIG. 36

FIG. 37

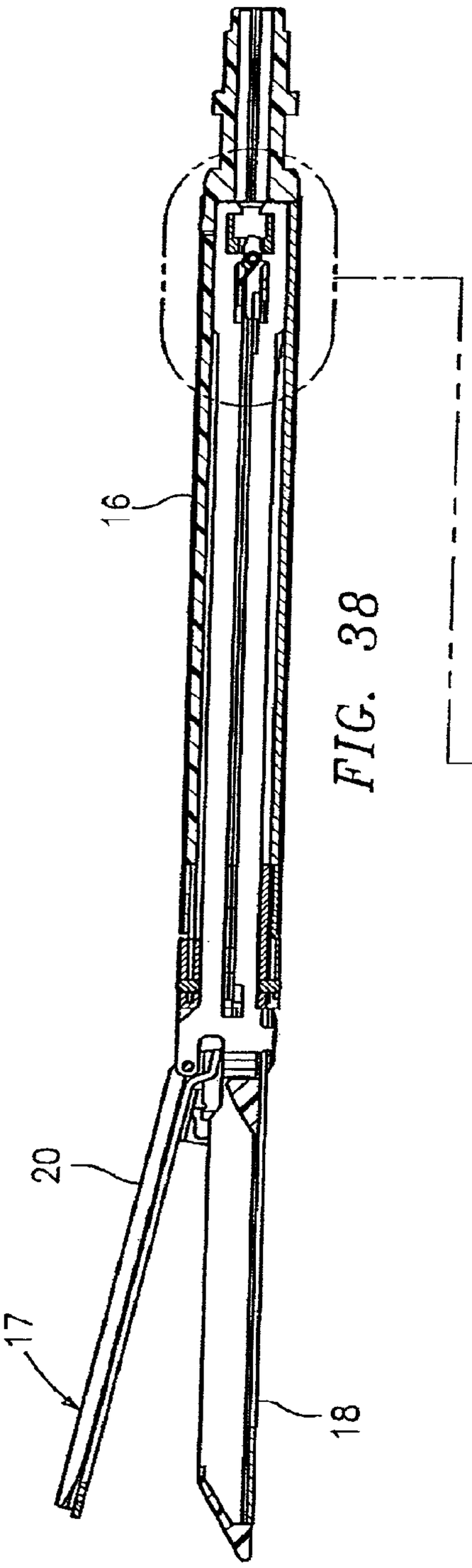


FIG. 38

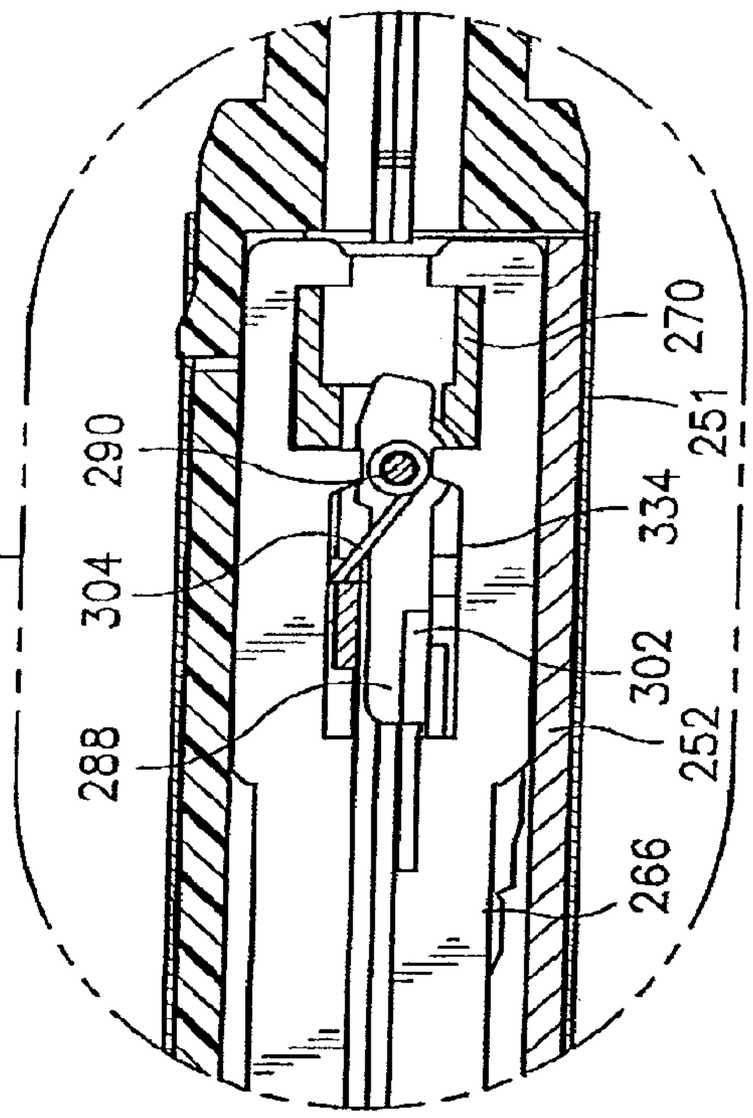


FIG. 39

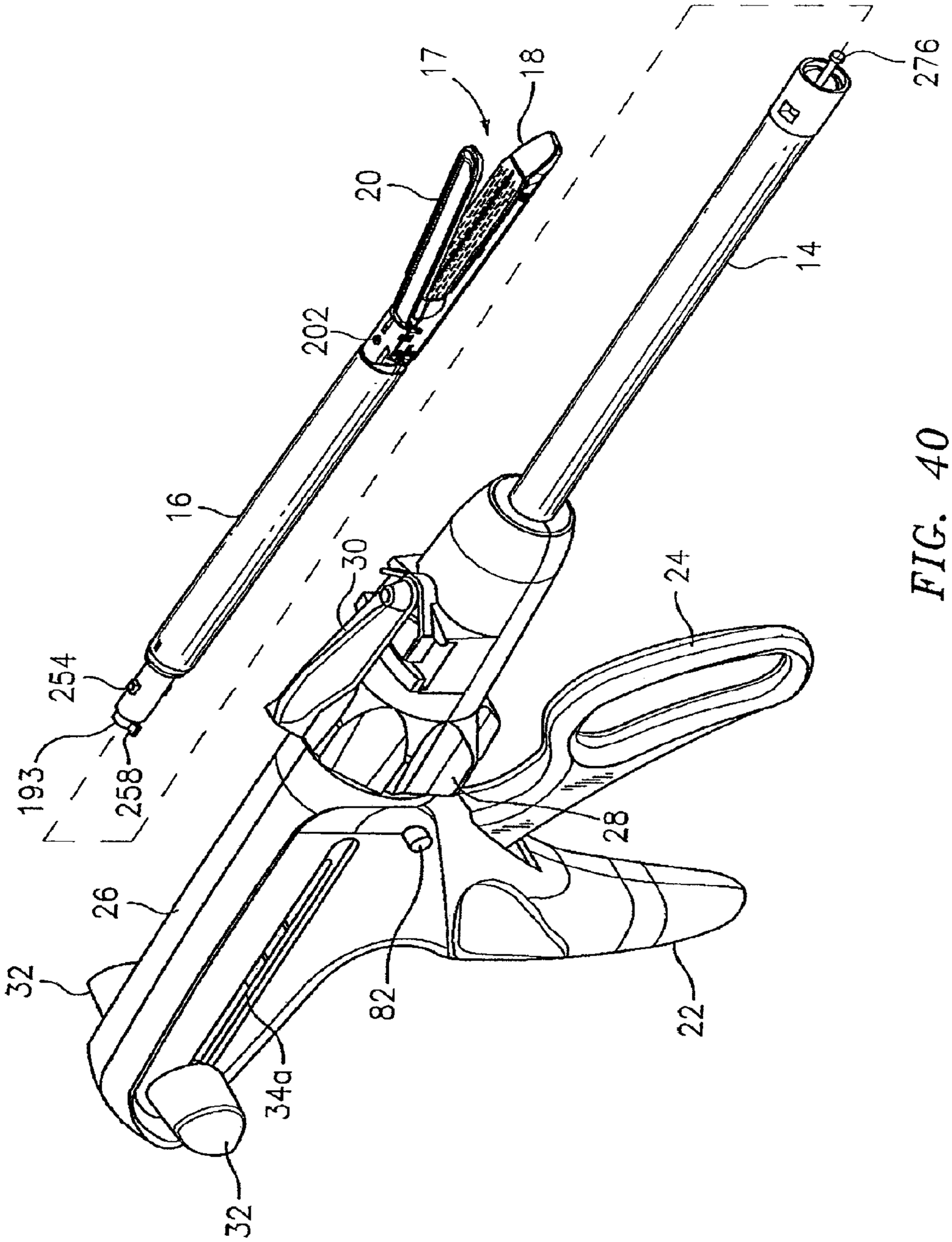


FIG. 40

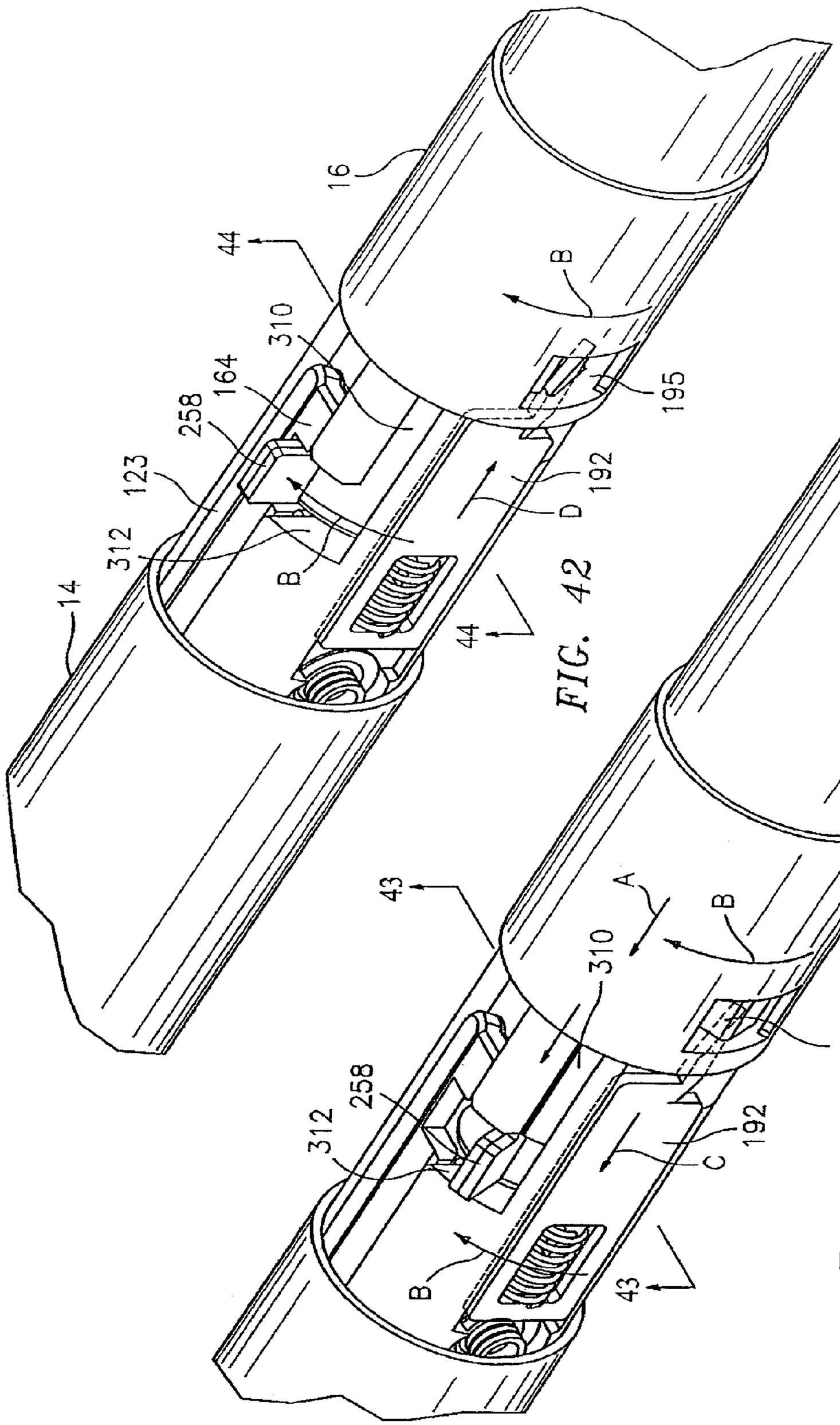


FIG. 42

FIG. 41

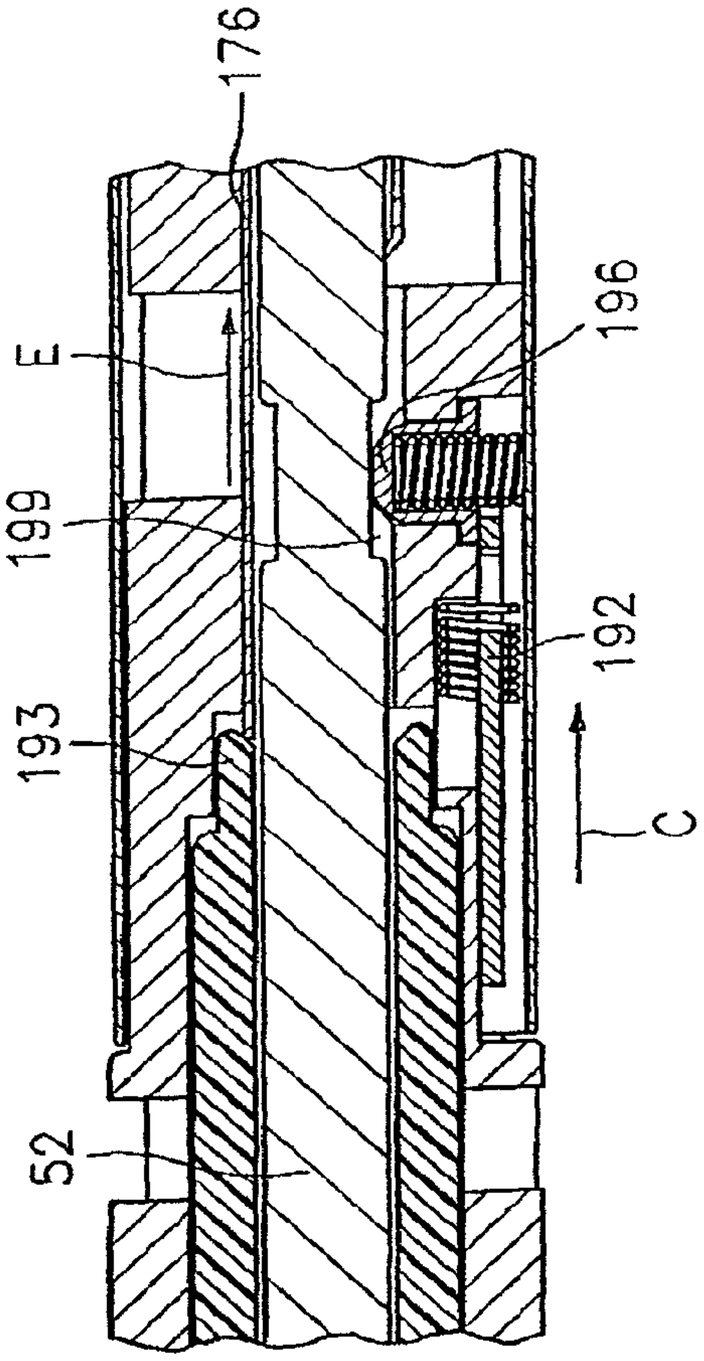

176
E
196
199
192
193
C
52

FIG. 43

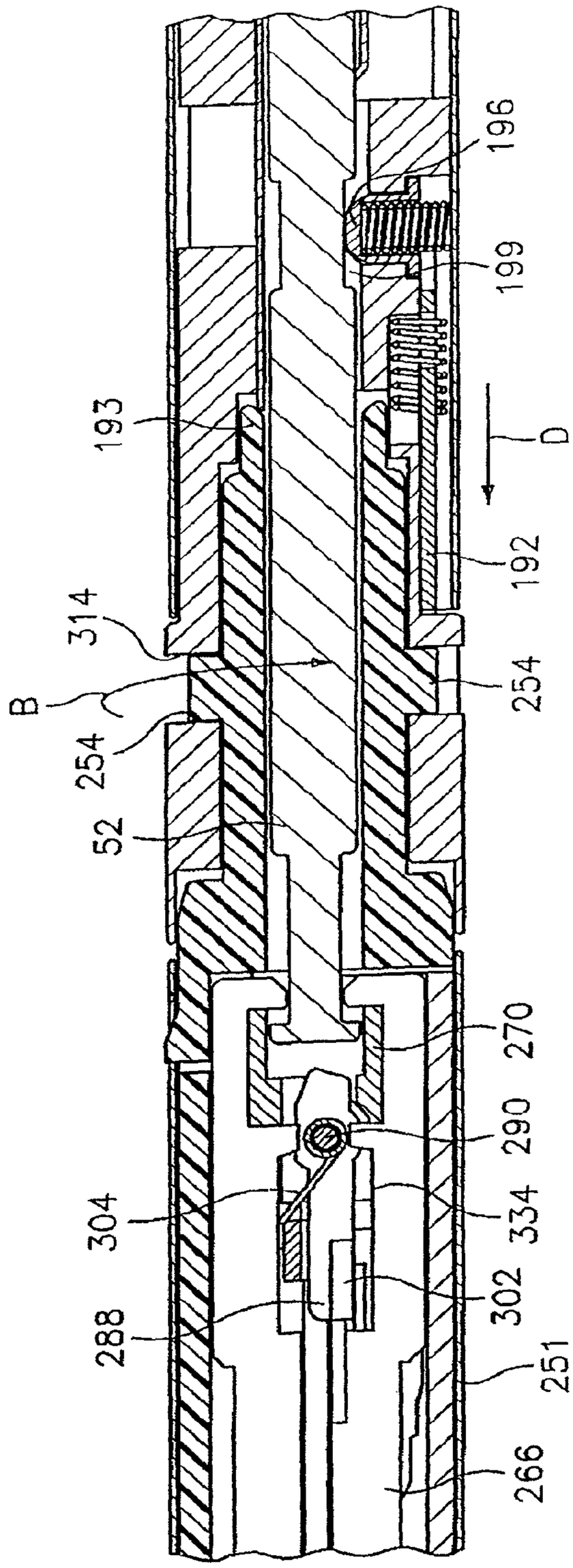

196
199
193
D
192
314
B
254
254
52
270
290
334
304
302
288
251
266

FIG. 44

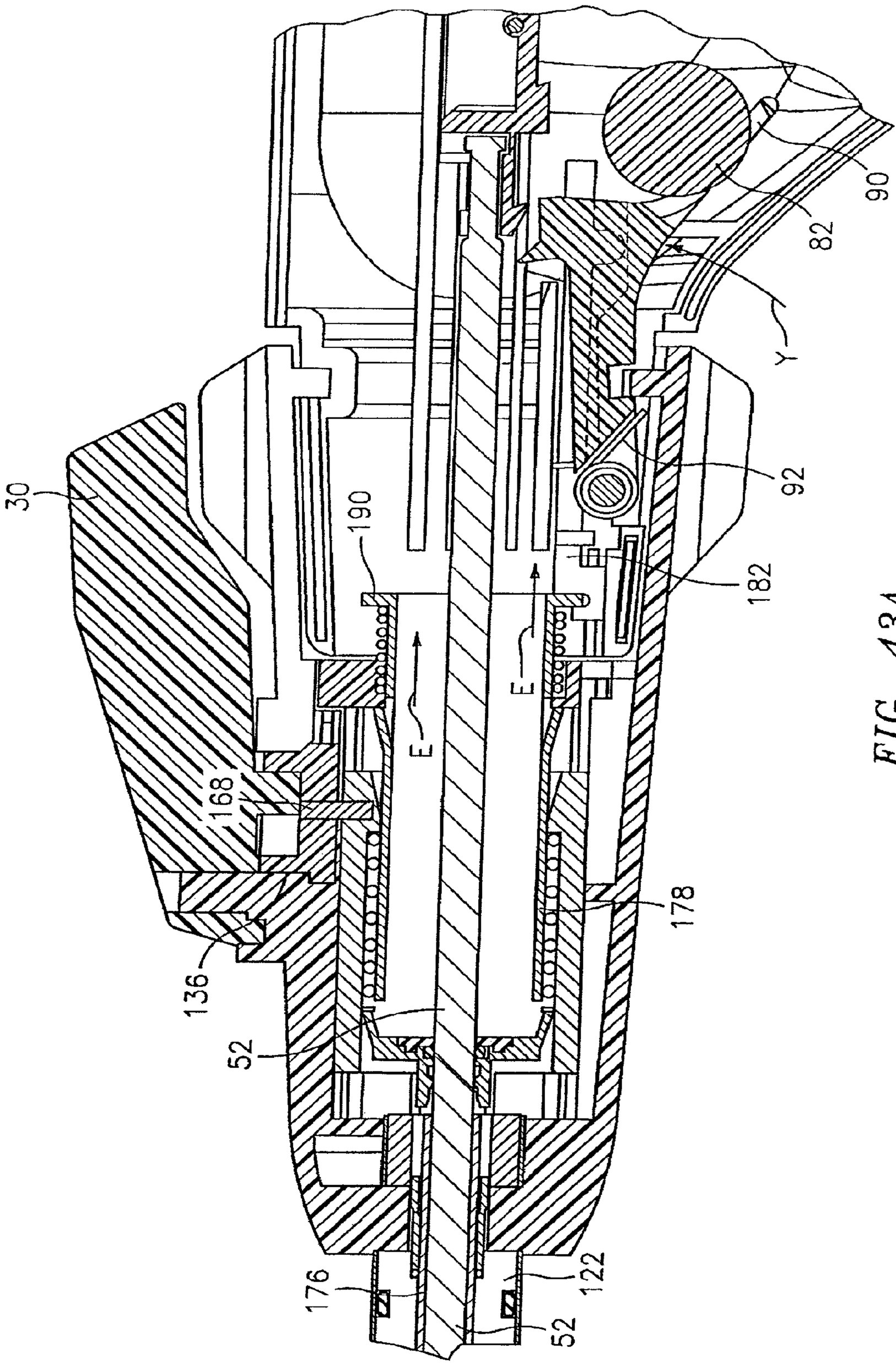


FIG. 43A

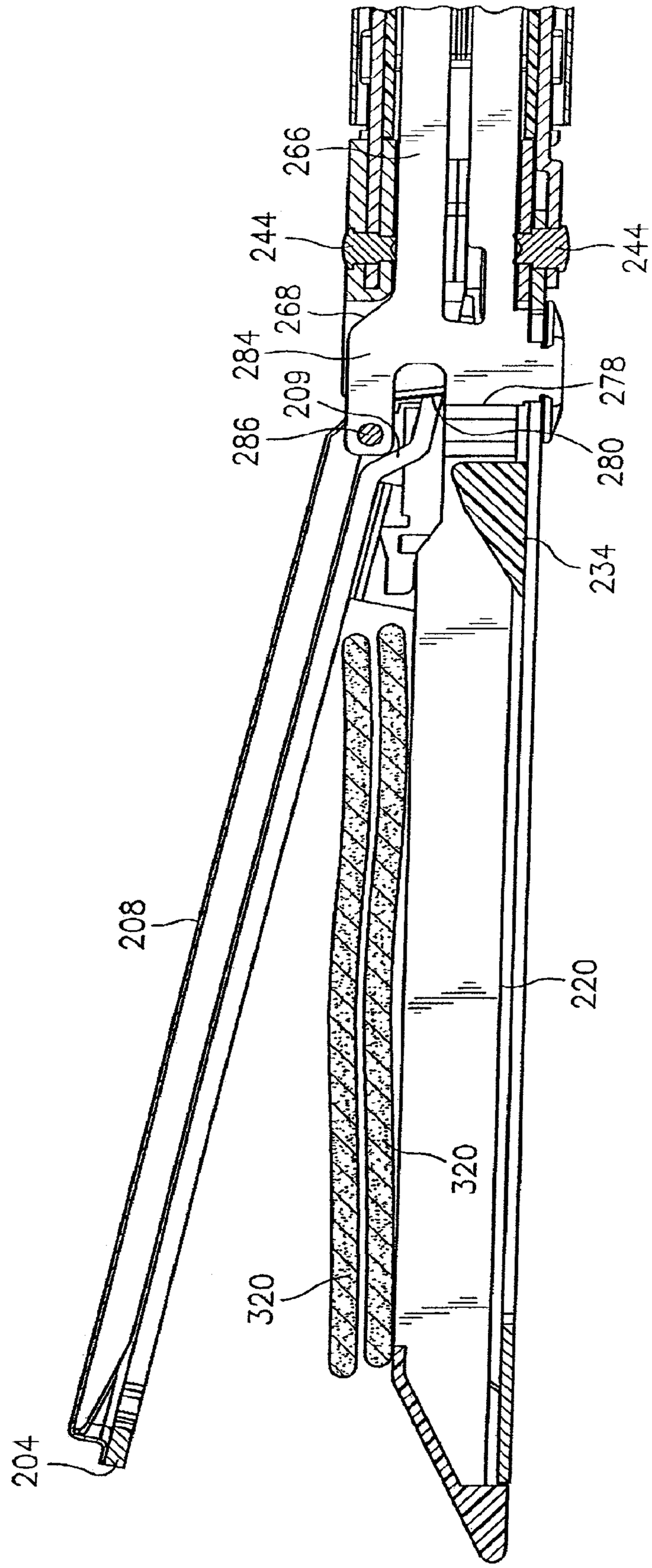


FIG. 45

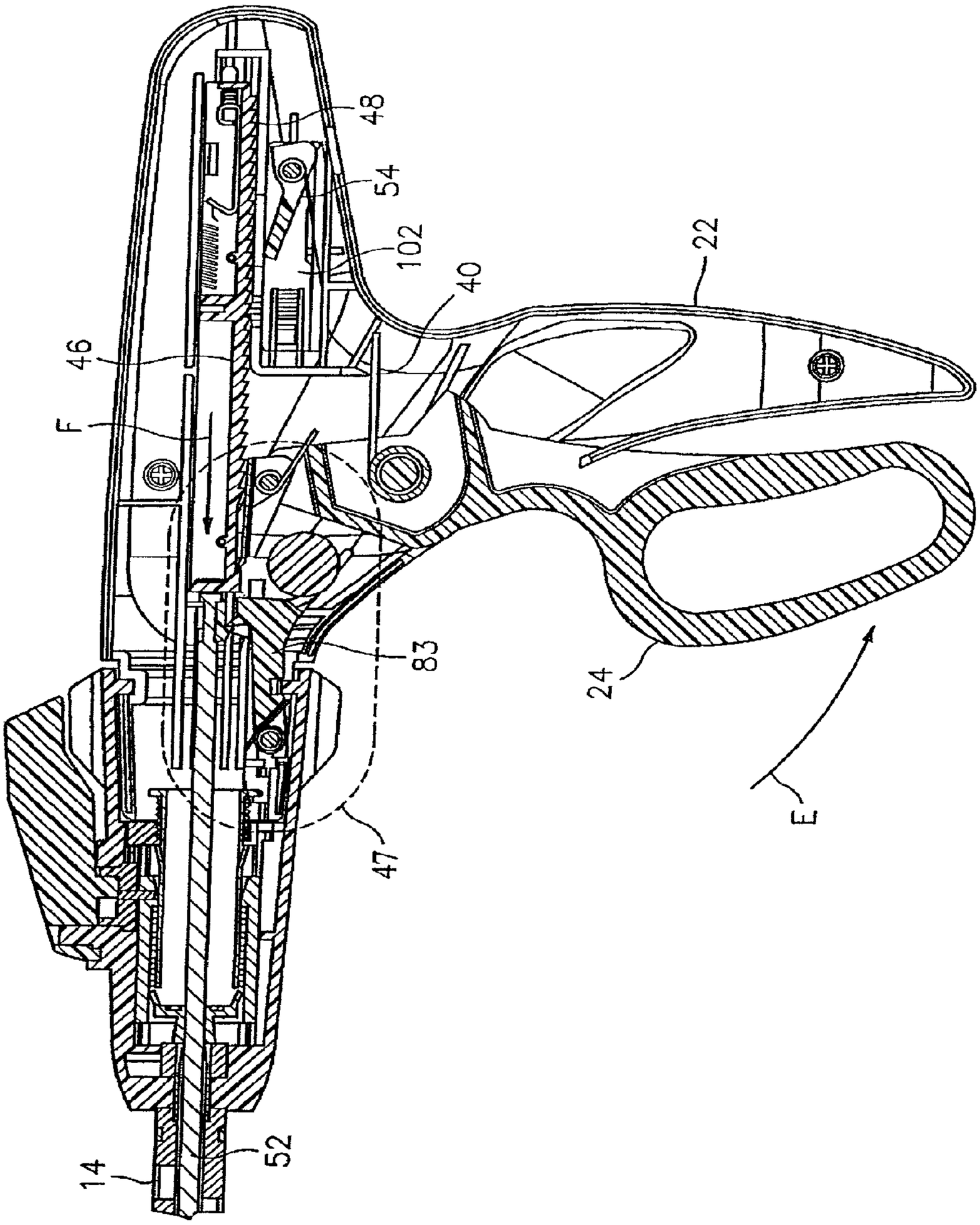


FIG. 46

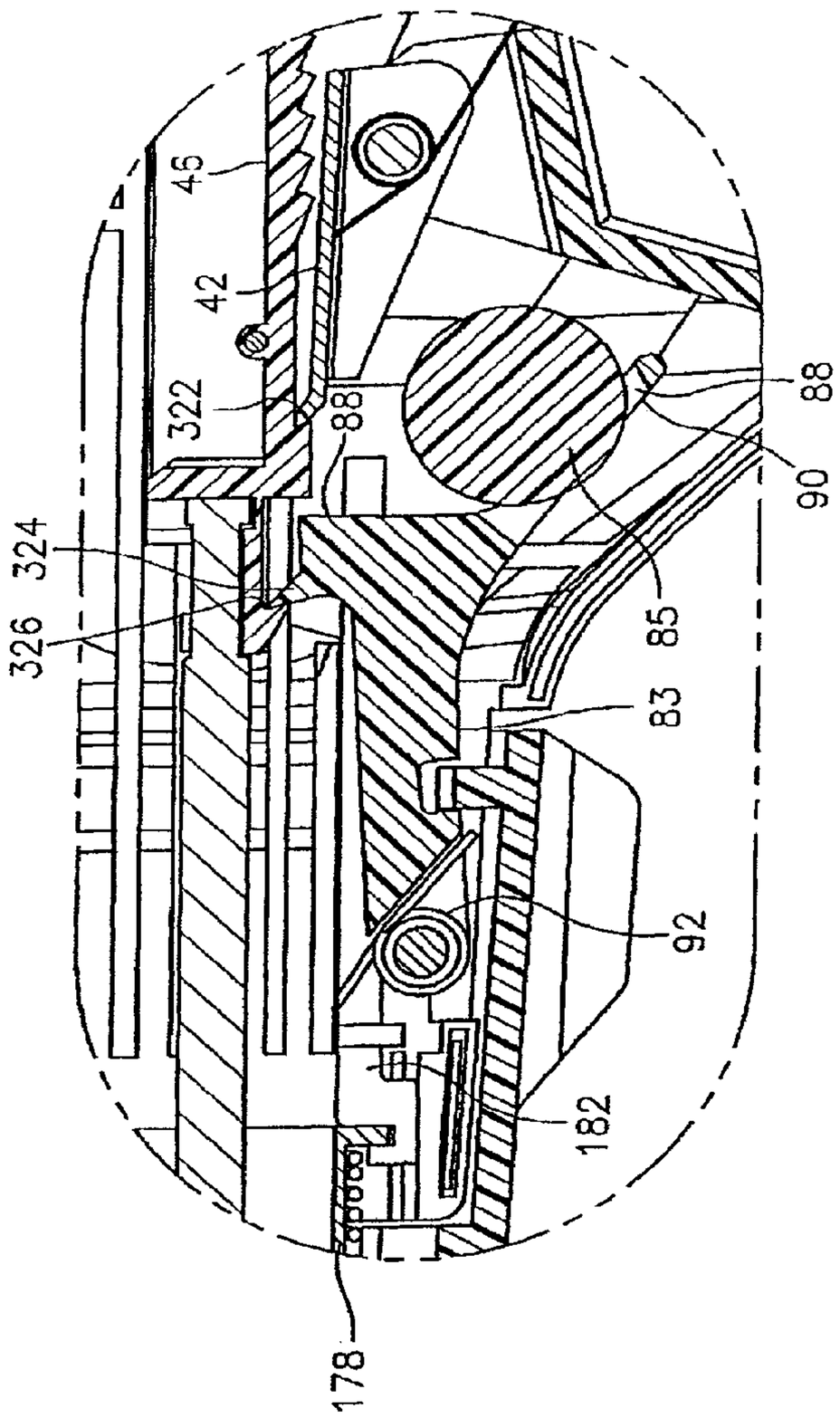


FIG. 47

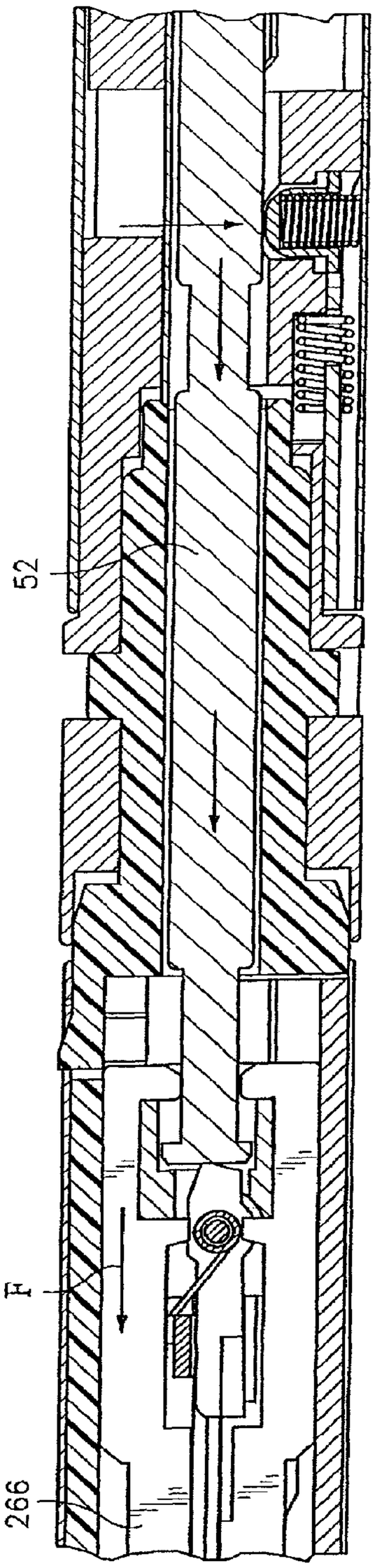


FIG. 48

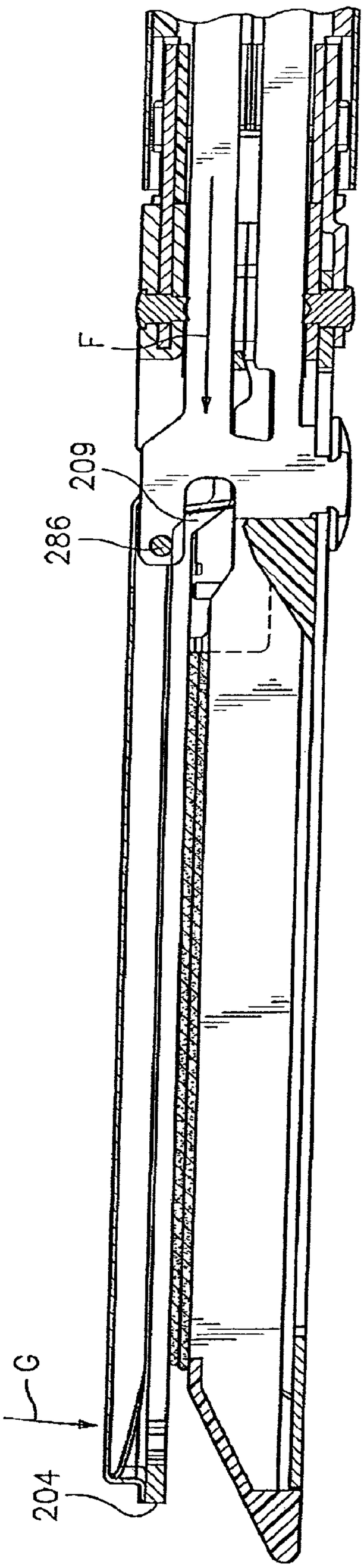


FIG. 49

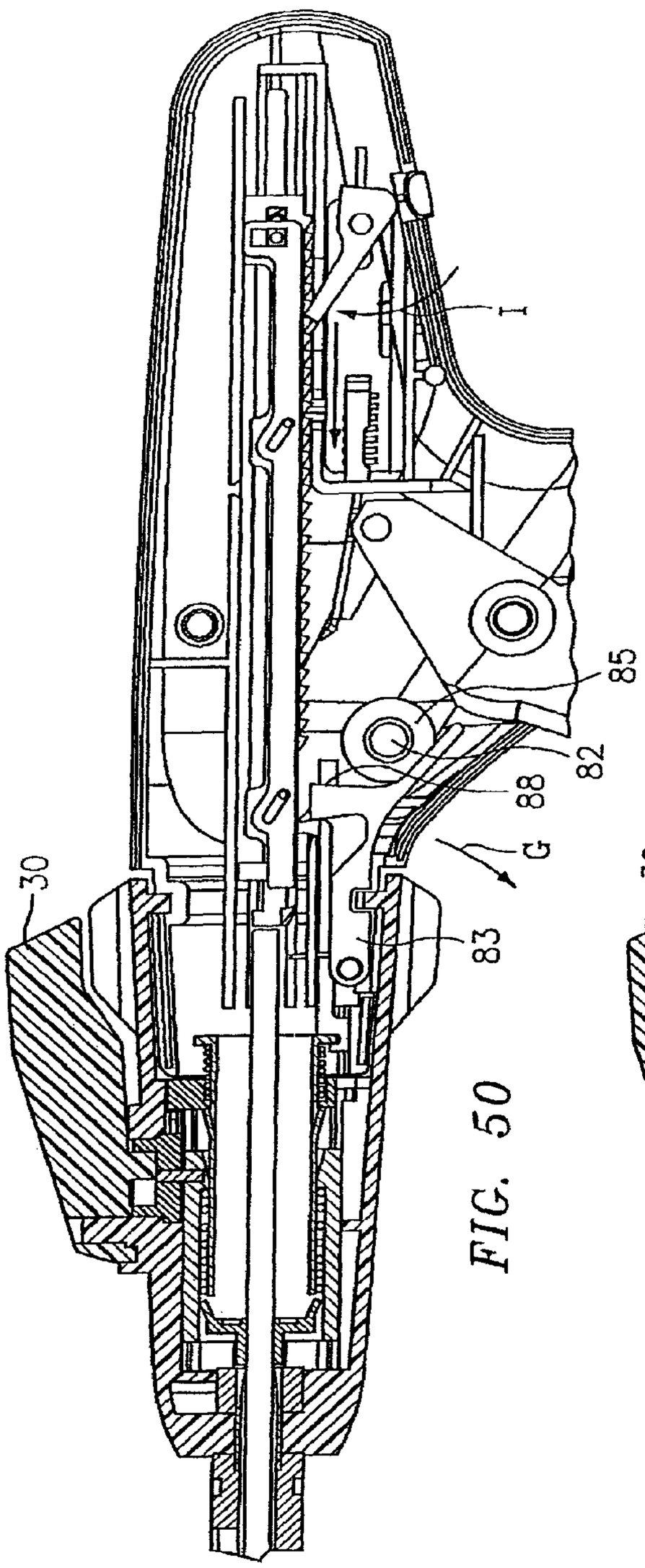


FIG. 50

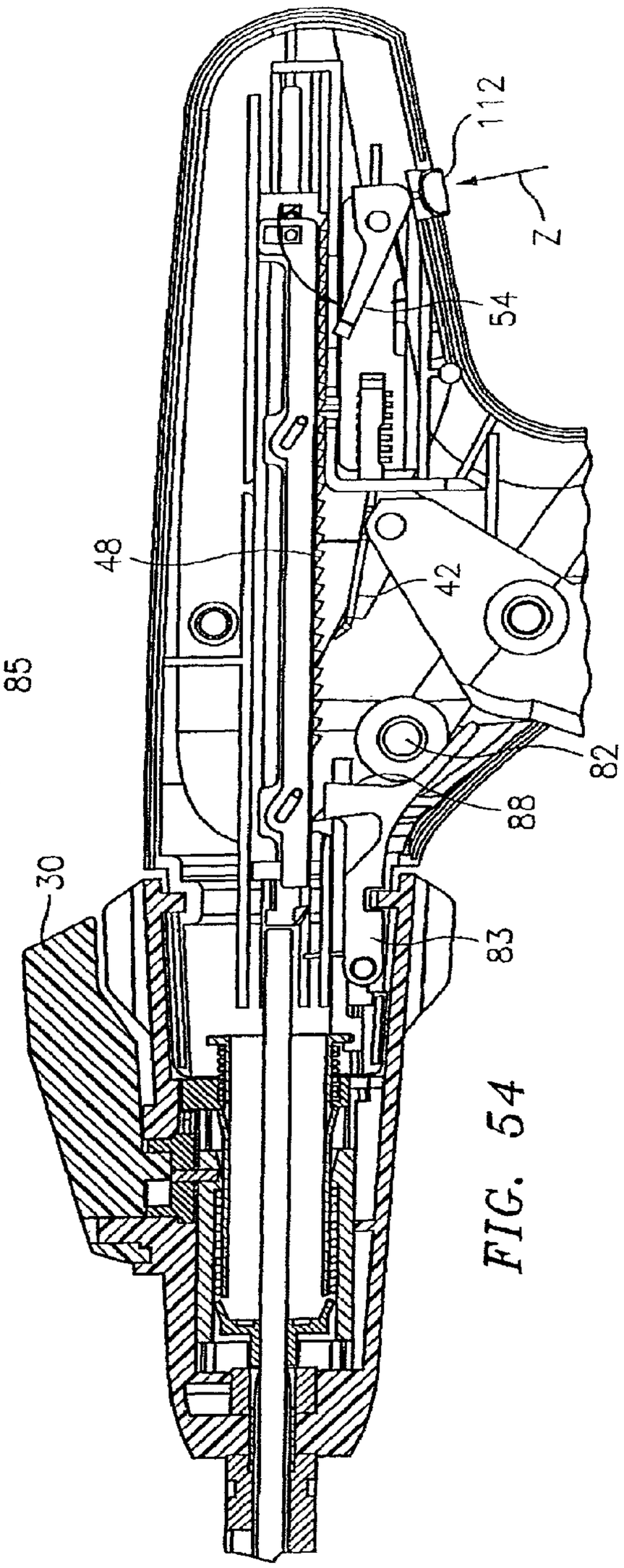


FIG. 54

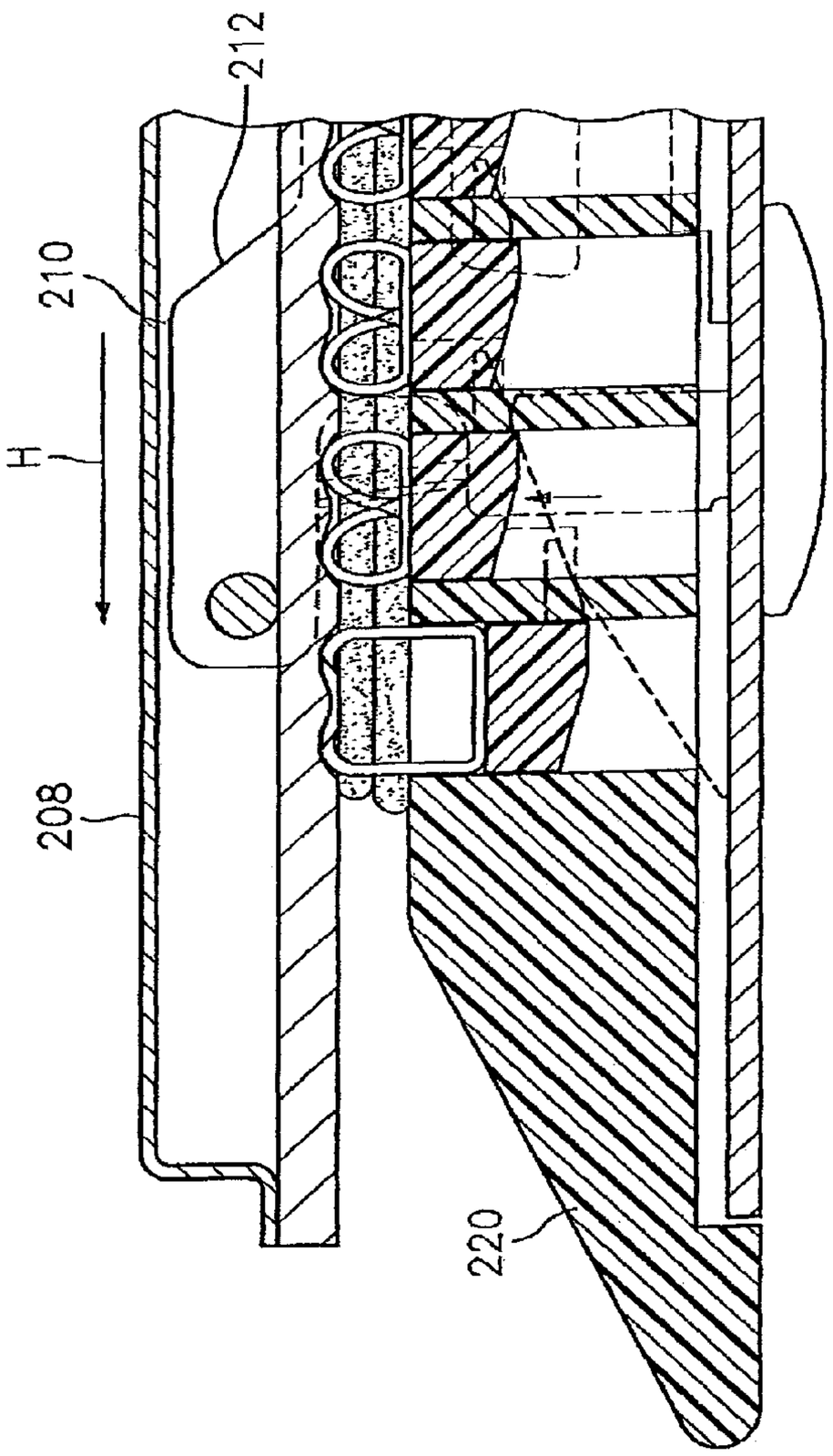


FIG. 51

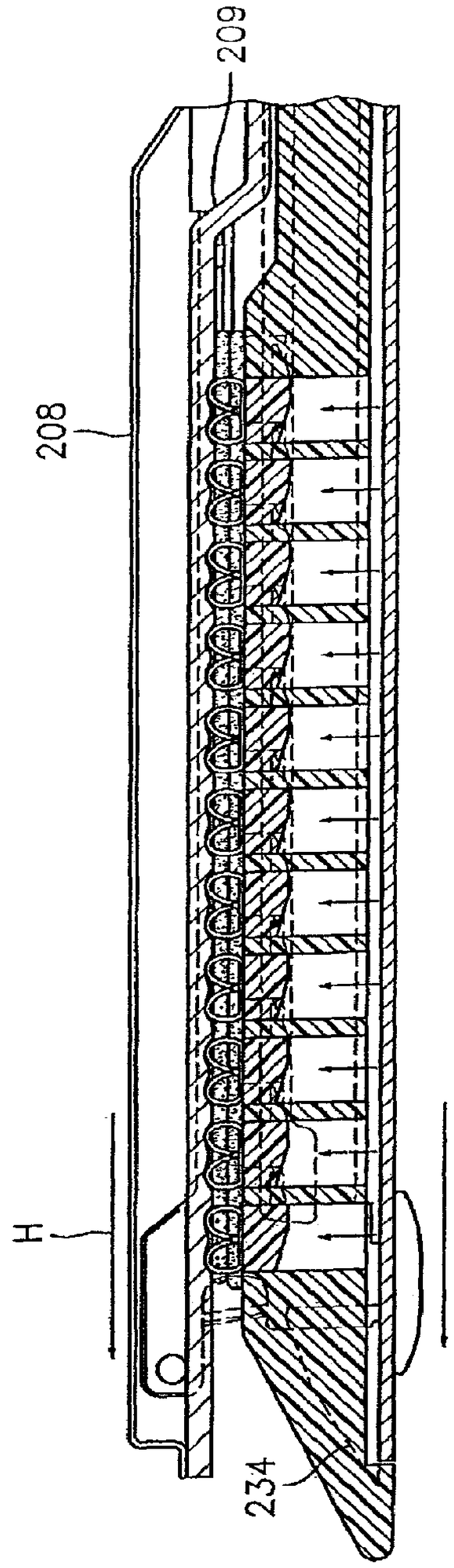


FIG. 52

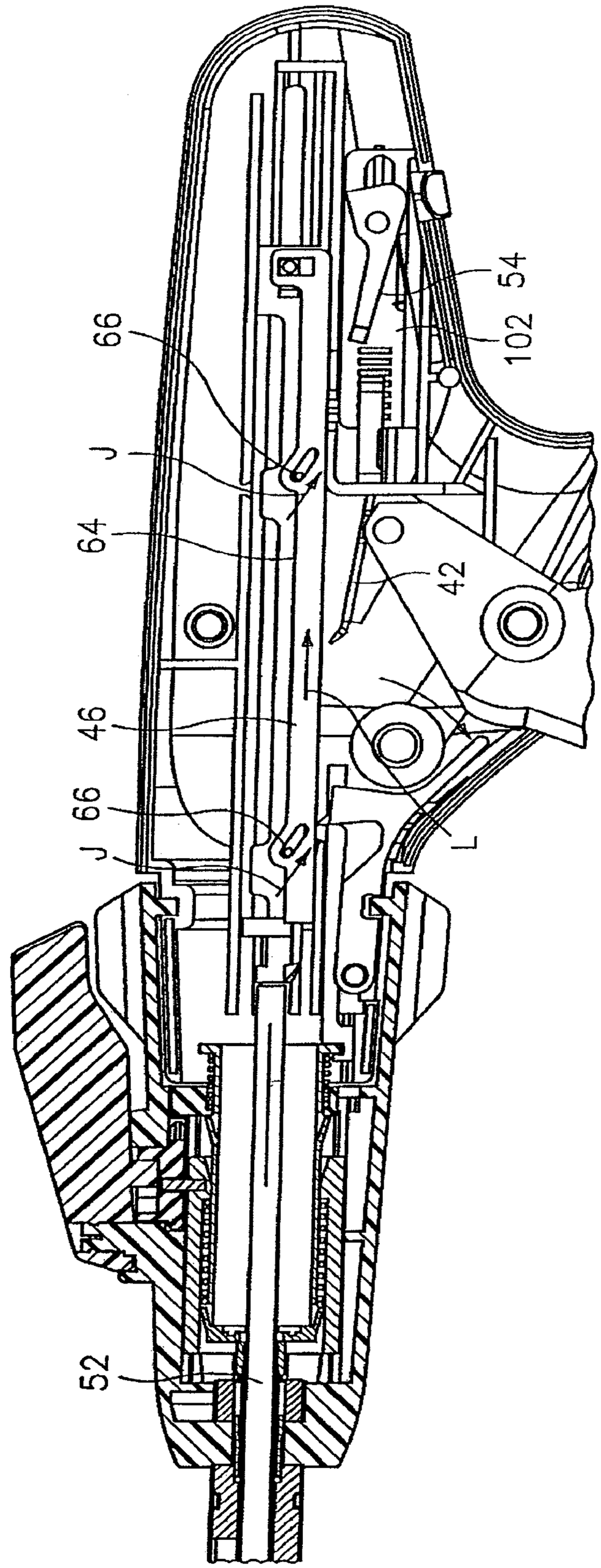


FIG. 53

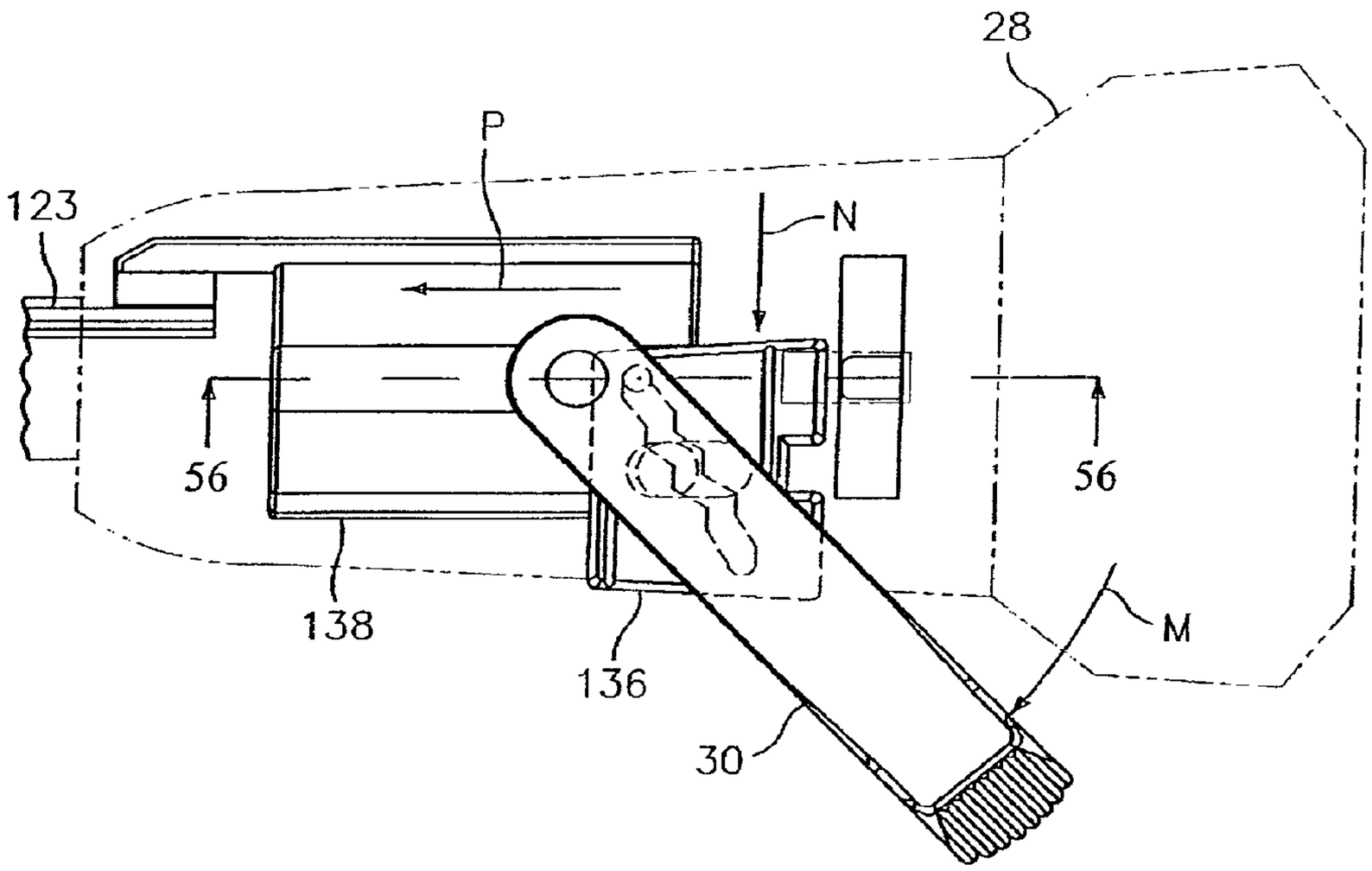


FIG. 55

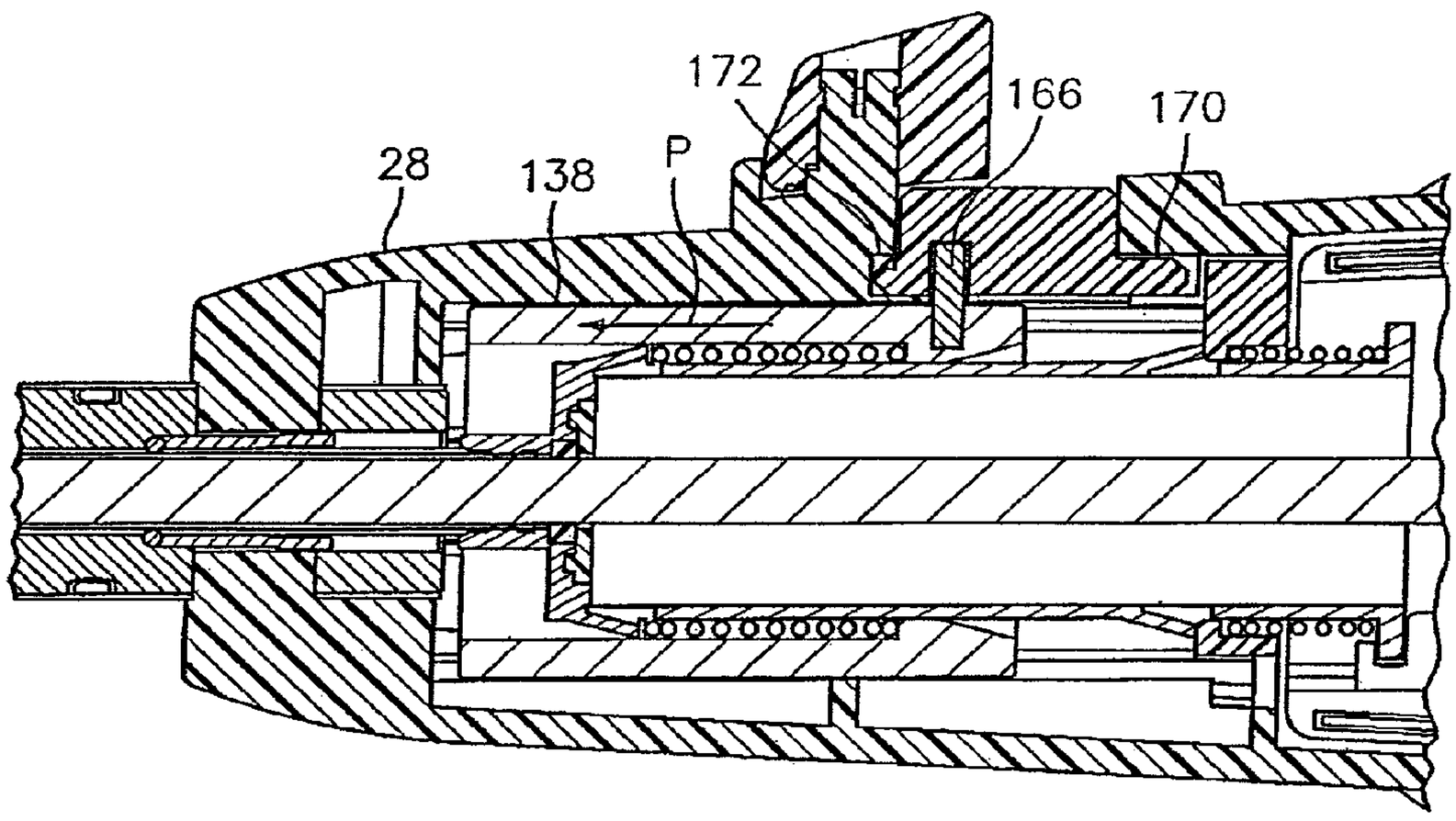


FIG. 56

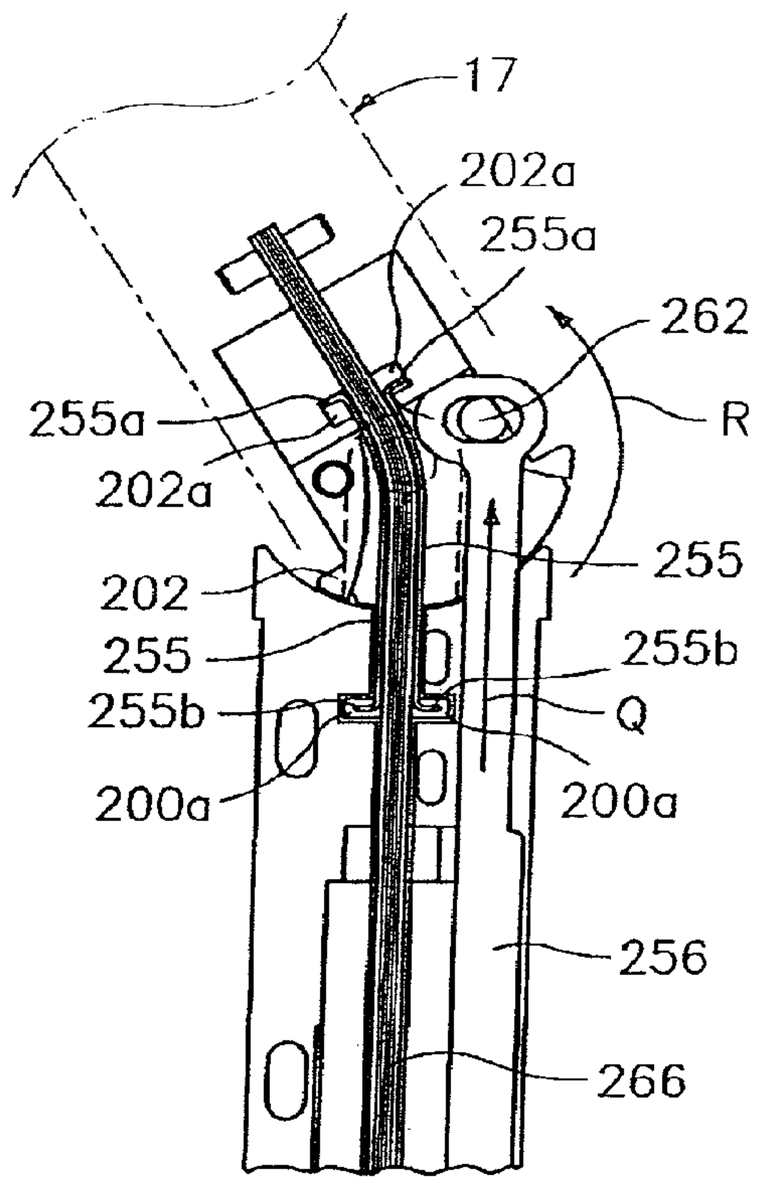


FIG. 57

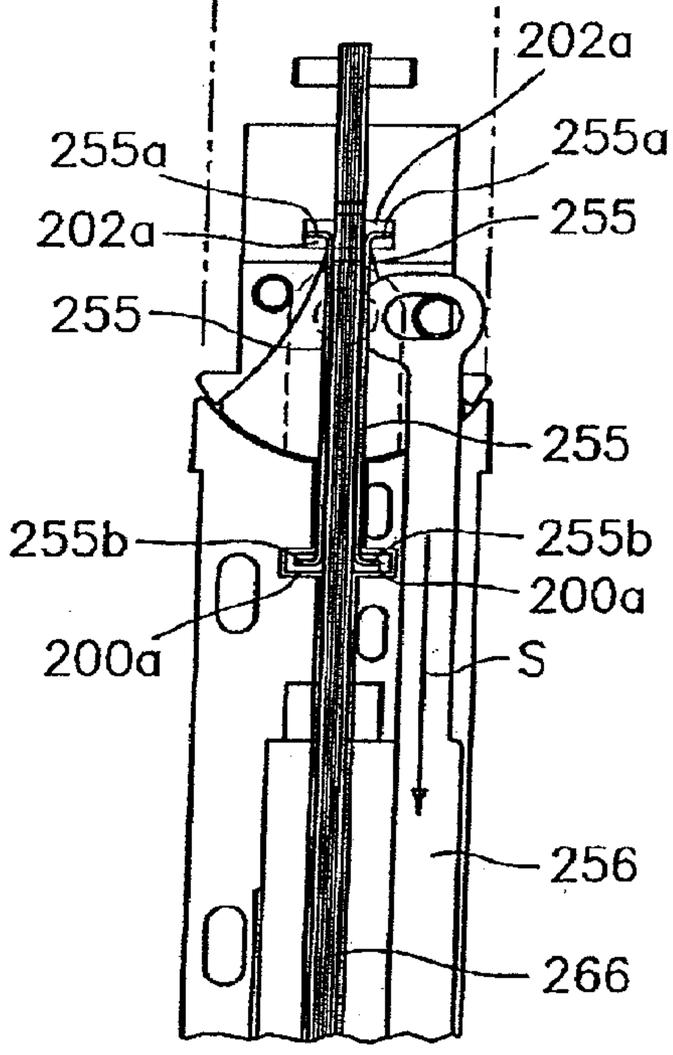


FIG. 60

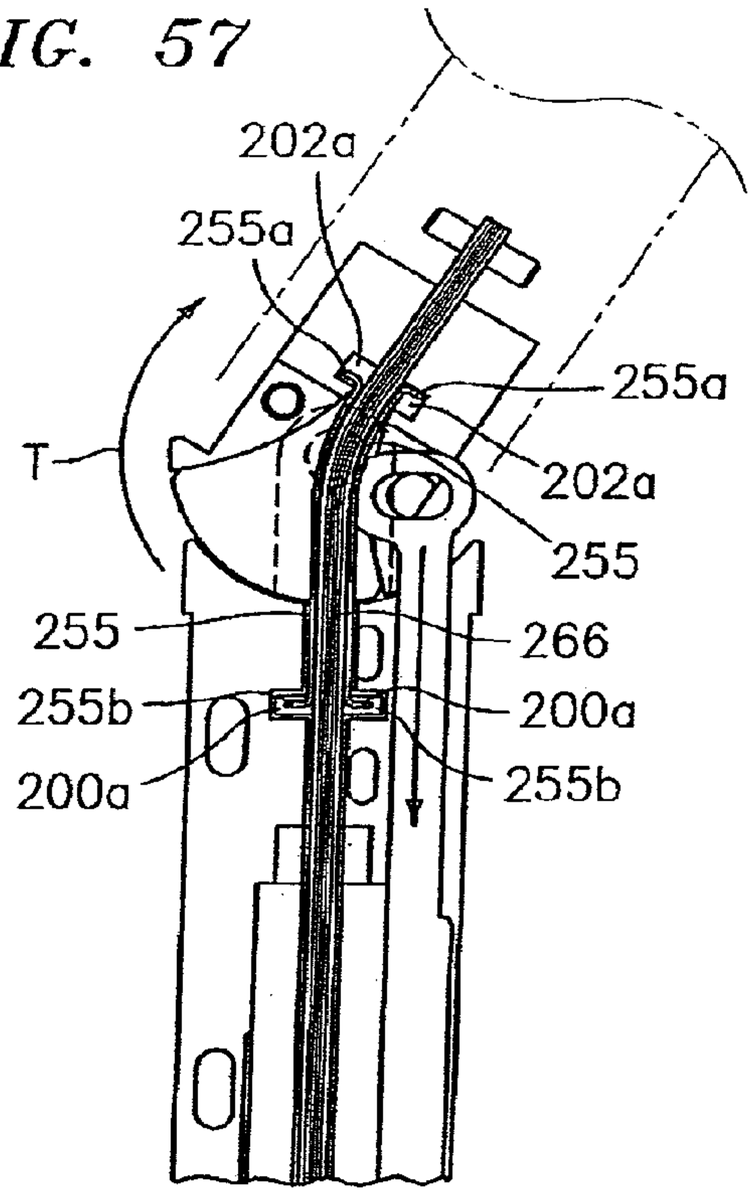


FIG. 61

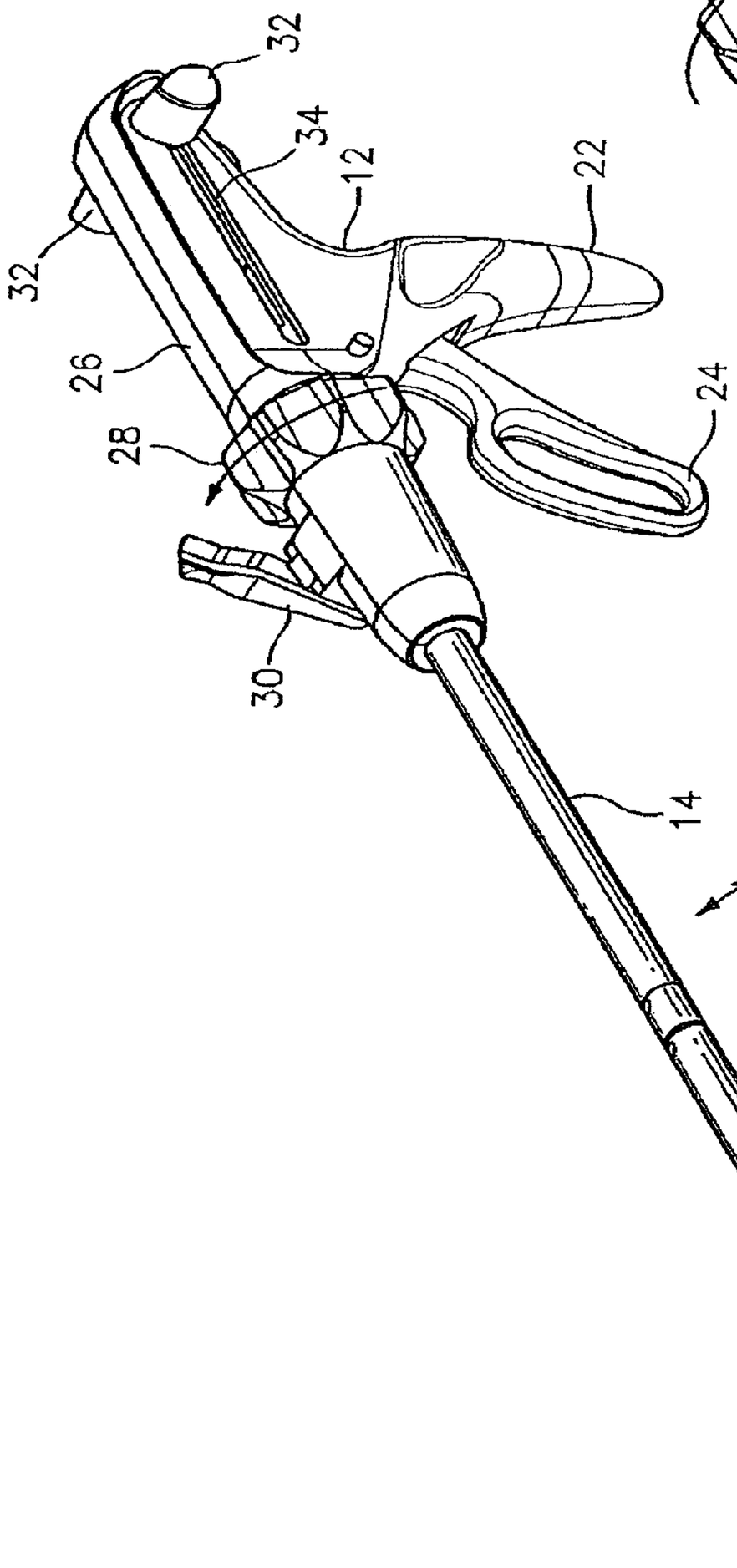

32
34
12
22
32
26
28
24
30
14
10
16
18
20
17

FIG. 59

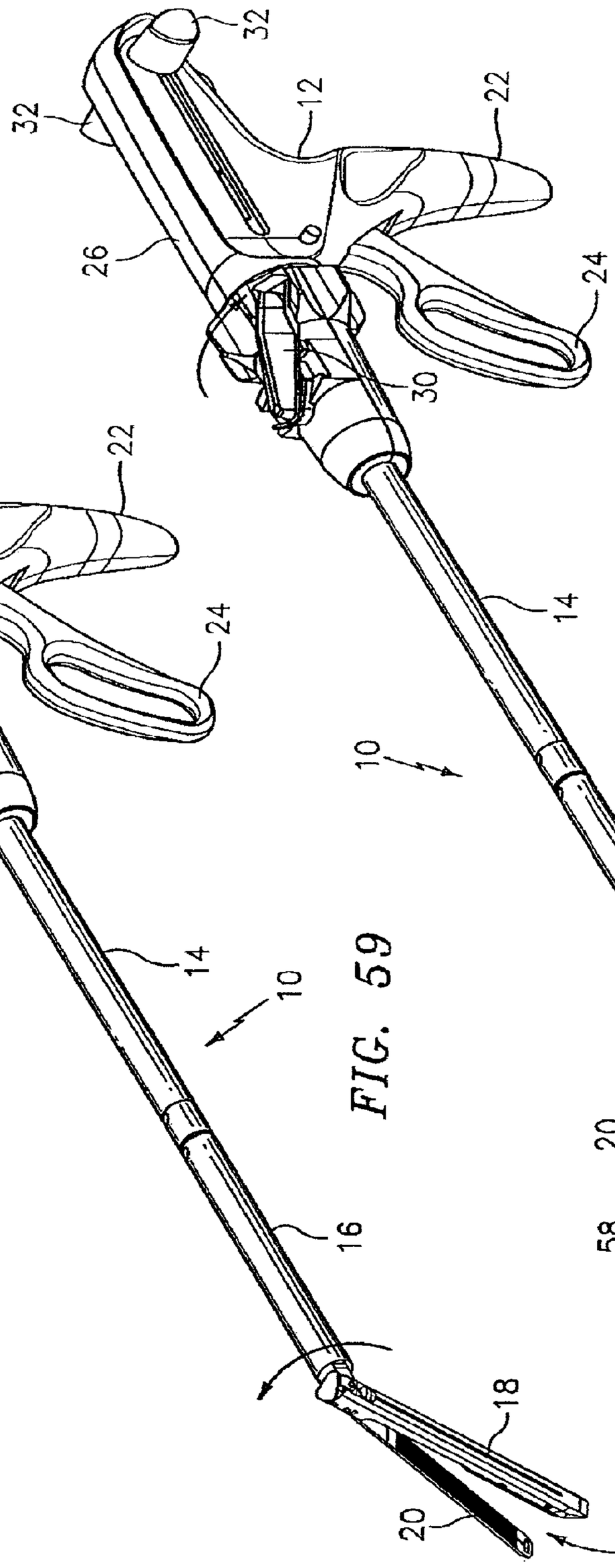

32
12
22
32
26
24
30
14
10
16
20
58
18

FIG. 58

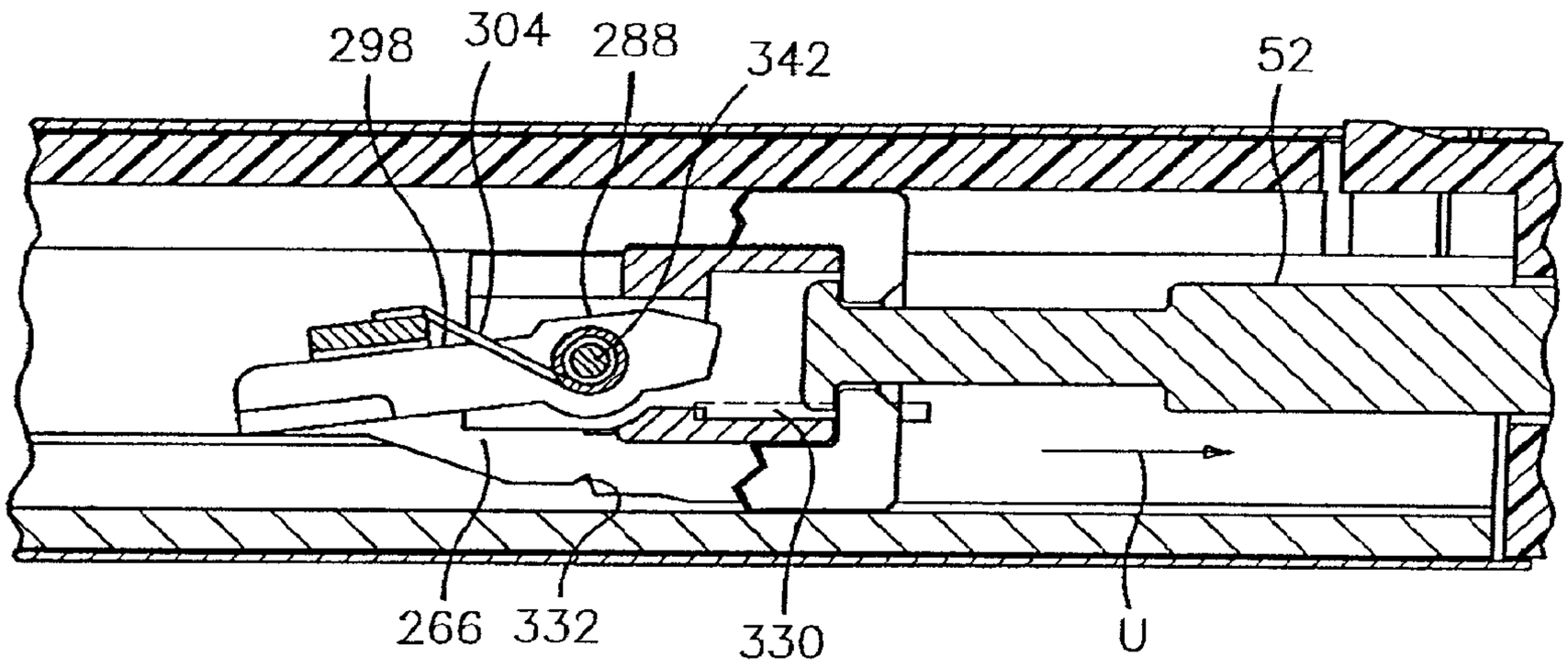


FIG. 62

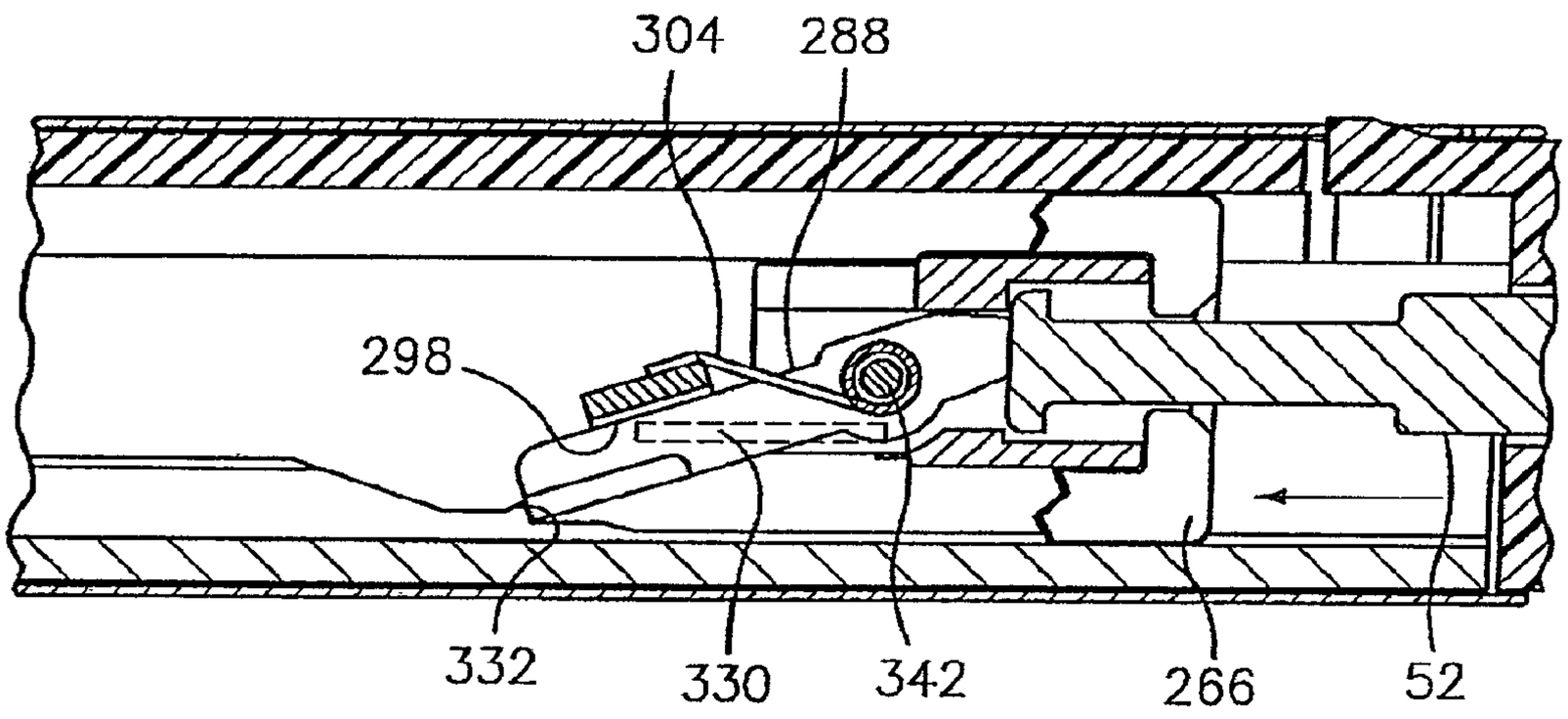


FIG. 63

SURGICAL STAPLING APPARATUS INCLUDING SENSING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13,585,350, filed on Aug. 14, 2012, now U.S. Pat. No. 8,342,377 which is a continuation of U.S. patent application Ser. No. 13/491,085, filed on Jun. 7, 2012, now U.S. Pat. No. 8,292,152, which is a continuation of U.S. patent application Ser. No. 13/295,140, filed on Nov. 14, 2011, now U.S. Pat. No. 8,256,656, which is a continuation of U.S. patent application Ser. No. 13/285,355, filed on Oct. 31, 2011, now U.S. Pat. No. 8,210,416, which is a continuation of U.S. patent application Ser. No. 12/793,196, filed on Jun. 3, 2010, now U.S. Pat. No. 8,070,033, which is a continuation of U.S. patent application Ser. No. 12/494,617, filed on Jun. 30, 2009, now U.S. Pat. No. 8,083,118, which is a divisional of U.S. patent application Ser. No. 11/974,638, filed on Oct. 15, 2007, now U.S. Pat. No. 7,565,993, which is a continuation of U.S. patent application Ser. No. 11/489,212, filed on Jul. 19, 2006, now U.S. Pat. No. 7,303,107, which is a continuation of U.S. patent application Ser. No. 11/186,742, filed on Jul. 20, 2005, now abandoned, which is a continuation of U.S. patent application Ser. No. 10/983,288, filed on Nov. 5, 2004, now U.S. Pat. No. 6,953,139, which is a continuation of U.S. patent application Ser. No. 10/700,250, filed on Nov. 3, 2003, now abandoned, which is a continuation of U.S. patent application Ser. No. 10/014,004, filed on Dec. 10, 2001, now U.S. Pat. No. 6,669,073, which is a continuation of U.S. patent application Ser. No. 09/680,093, filed on Oct. 5, 2000, now U.S. Pat. No. 6,330,965, which is a divisional of U.S. patent application Ser. No. 09/561,567, filed on Apr. 28, 2000, now U.S. Pat. No. 6,241,139, which is a divisional of U.S. patent application Ser. No. 09/166,378, filed on Oct. 5, 1998, now U.S. Pat. No. 6,079,606, which is a divisional of U.S. patent application Ser. No. 08/935,980, filed on Sep. 23, 1997, now U.S. Pat. No. 5,865,361. The entire content of each application identified above is hereby incorporated by reference.

BACKGROUND

1. Technical Field

This application relates to a surgical stapling apparatus, and more particularly, to an articulating mechanism for use with an endoscopic surgical stapling apparatus for sequentially applying a plurality of surgical fasteners to body tissue and optionally incising fastened tissue.

2. Background of Related Art

Surgical devices wherein tissue is first grasped or clamped between opposing jaw structure and then joined by surgical fasteners are well known in the art. In some instruments a knife is provided to cut the tissue which has been joined by the fasteners. The fasteners are typically in the form of surgical staples but two part polymeric fasteners can also be utilized.

Instruments for this purpose can include two elongated members which are respectively used to capture or clamp tissue. Typically, one of the members carries a staple cartridge which houses a plurality of staples arranged in at least two lateral rows while the other member has an anvil that defines a surface for forming the staple legs as the staples are driven from the staple cartridge. Generally, the stapling operation is effected by cam bars that travel longitudinally through the staple cartridge, with the cam bars acting upon staple pushers to sequentially eject the staples from the staple cartridge. A knife can travel between the staple rows to longitudinally cut and/or open the stapled tissue between the rows of staples. Such instruments are disclosed, for example, in U.S. Pat. No. 3,079,606 and U.S. Pat. No. 3,490,675.

A later stapler disclosed in U.S. Pat. No. 3,499,591 applies a double row of staples on each side of the incision. This is accomplished by providing a disposable loading unit in which a cam member moves through an elongate guide path between two sets of staggered staple carrying grooves. Staple drive members are located within the grooves and are positioned in such a manner so as to be contacted by the longitudinally moving cam member to effect ejection of the staples from the staple cartridge of the disposable loading unit. Other examples of such staplers are disclosed in U.S. Pat. Nos. 4,429,695 and 5,065,929.

Each of the instruments described above were designed for use in conventional surgical procedures wherein surgeons have direct manual access to the operative site. However, in endoscopic or laparoscopic procedures, surgery is performed through a small incision or through a narrow cannula inserted through small entrance wounds in the skin. In order to address the specific needs of endoscopic and/or laparoscopic surgical procedures, endoscopic surgical stapling devices have been developed and are disclosed in, for example, U.S. Pat. Nos. 5,040,715 (Green, et al.); 5,307,976 (Olson, et al.); 5,312,023 (Green, et al.); 5,318,221 (Green, et al.); 5,326,013 (Green, et al.); and 5,332,142 (Robinson, et al.).

U.S. Surgical, the assignee of the present application, has manufactured and marketed endoscopic stapling instruments, such as the Multifire ENDO GIA* 30 and Multifire ENDO GIA* 60 instruments, for several years. These instruments have provided significant clinical benefits. Nonetheless, improvements are possible, for example, by reducing the cost and complexity of manufacture.

Current laparoscopic linear stapling devices are configured to operate with disposable loading units (U.S. Surgical) and staple cartridges (Ethicon) of only one size. For example, individual linear staplers are presently available for applying parallel rows of staples measuring 30 mm, 45 mm and 60 mm in length. Thus, during a normal operation, a surgeon may be required to utilize several different stapling instruments to perform a single laparoscopic surgical procedure. Such practices increase the time, complexity and overall costs associated with laparoscopic surgical procedures. In addition, costs are greater in designing and manufacturing multiple stapler sizes, as opposed to creating a single, multipurpose stapler.

It would be extremely beneficial to provide a surgical device for use during laparoscopic and/or endoscopic surgical procedures that can be employed with several different sized disposable loading units to reduce the overall costs associated with such procedures. It would also be particularly beneficial if the device could perform multiple tasks, using disposable loading units of varying size and of varying purpose, such as, for example, to staple, clip, cut and/or articulate.

In making improvements or modifications to the current instruments, it would be highly desirable not to sacrifice any of the important benefits of the MULTIFIRE ENDO GIA* 30 and 60 instruments as compared to other commercially available products, e.g., the endoscopic stapling instruments manufactured and marketed by Ethicon, Inc. For example, any improvement should advantageously provide a fresh knife blade for each firing of the instrument and ensure that the disposable loading unit is securely retained in the stapling instrument unless and until the operating team chooses to remove it. These advantages have historically been found in the U.S. Surgical instruments, but not in the Ethicon instruments.

SUMMARY

In accordance with the present disclosure, a surgical stapling apparatus for sequentially applying a plurality of fasteners to body tissue and simultaneously incising tissue is provided. The surgical stapling apparatus is adapted to receive disposable loading units having rows of staples having a linear length of between 30 mm and 60 mm. The surgical stapling apparatus is also adapted to receive articulating and non-articulating disposable loading units.

The surgical stapling apparatus includes a handle assembly having a movable handle and a stationary handle. The movable handle is movable through an actuation stroke to clamp tissue and to effect ejection of staples from the disposable loading unit. An elongated body extends distally from the handle assembly and defines a longitudinal axis. An actuation shaft having a toothed rack is operably associated with the movable handle by a pawl mechanism. The distal end of the actuation shaft is connected to a control rod having a distal end adapted to operatively engage an axial drive assembly located within a disposable loading unit.

The stapling apparatus includes an articulation mechanism having an articulation lever operatively engaged with a cam member having a stepped camming channel. The cam member is engaged with a translation member which includes a pin dimensioned to be received within the stepped camming channel such that pivotable movement of the lever causes linear movement of the translation member. A first articulation link includes a proximal end adapted to engage the translation member and a distal end adapted to engage a second articulation link positioned within the disposable loading unit. Linear movement of the translation member causes linear movement of the articulation links to cause articulation of a tool assembly of the disposable loading unit.

The surgical stapling apparatus also preferably includes a sensing mechanism for sensing the type of disposable loading unit secured to the elongated body of the apparatus. The sensing mechanism includes a sensing tube positioned within the elongated body to engage a disposable loading unit secured to the elongated body. A sensing cylinder connected to the sensing tube engages a locking ring having a tab portion configured to engage the articulation mechanism in a first position to prevent movement of the articulation lever. The locking ring is moved by the sensing cylinder when an articulating disposable loading unit is secured to the elongated body of the stapling apparatus to a second position to disengage the tab portion from the articulation mechanism to permit movement of the articulation lever. In contrast, a non-articulating disposable loading unit will not unlock the articulation lever.

BRIEF DESCRIPTION OF THE DRAWINGS

Various preferred embodiments are described herein with reference to the drawings:

FIG. **1** is a perspective view of one preferred embodiment of the presently disclosed surgical stapling apparatus;

FIG. **2** is a top view of the surgical apparatus shown in FIG. **1**;

FIG. **3** is a side view of the surgical apparatus shown in FIG. **1**;

FIG. **4** is a perspective view with parts separated of the handle assembly of the surgical apparatus shown in FIG. **1**;

FIG. **5** is a cross-sectional view of a portion of the firing lockout mechanism shown in FIG. **4**;

FIG. **6** is a perspective of the slide plate of the anti-reverse clutch mechanism of the surgical apparatus;

FIG. **7** is an enlarged perspective view of the anti-reverse clutch mechanism shown in FIG. **1**;

FIG. **8** is a side cross-sectional view of the surgical stapling apparatus shown in FIG. **1** in the non-actuated position with the disposable loading unit removed;

FIG. **9** is a perspective view with parts separated of the rotation member, the articulation mechanism, and the elongated body of the surgical stapling apparatus shown in FIG. **1**;

FIG. **10** is an enlarged view of the indicated area of detail shown in FIG. **8**;

FIG. **10***a* is a perspective view of the translation member of the articulating mechanism and the proximal end of the elongated body of the surgical stapling apparatus shown in FIG. **1**;

FIG. **10***b* is an enlarged cross-sectional view of the indicated area of detail of FIG. **8**;

FIG. **10***c* is a cross-sectional view along section line **10***c*-**10***c* of FIG. **8**;

FIG. **11** is a perspective view of the cam member of the articulation mechanism of the surgical stapling apparatus shown in FIG. **1**;

FIG. **12** is a top view of the cam member of the articulation mechanism of the surgical stapling apparatus shown in FIG. **1**;

FIG. **12***a* is a perspective view of a non-articulating disposable loading unit usable with the surgical stapling apparatus shown in FIG. **1**;

FIG. **12***b* is a perspective view of the preferred articulating disposable loading unit of the surgical stapling apparatus shown in FIG. **1**;

FIG. **13** is a cross-sectional view taken along section line **13-13** of FIG. **10**;

FIG. **14** is a cross-sectional view taken along section line **14-14** of FIG. **10**;

FIG. **15** is a cross-sectional view taken along section line **15-15** of FIG. **10**;

FIG. **16** is an enlarged view of the indicated area of detail shown in FIG. **8**;

FIG. **17** is a side perspective view of the blocking plate of the surgical stapling apparatus shown in FIG. **1**;

FIG. **18** is a top perspective view of the blocking plate of the surgical stapling apparatus shown in FIG. **1**;

FIG. **19** is a perspective view of a disposable loading unit usable with the surgical stapling apparatus of FIG. **1**;

FIG. **20** is another perspective view of a disposable loading unit usable with the surgical stapling apparatus of FIG. **1**;

FIG. **21** is a perspective view of the tool assembly of the surgical stapling apparatus of FIG. **1** with parts separated;

FIG. **22** is an enlarged perspective view of the distal end of the anvil assembly showing a plurality of staple deforming cavities;

FIG. **23** is an enlarged perspective view of the distal end of the staple cartridge of the surgical stapling apparatus shown in FIG. **1**;

FIG. **24** is a side cross-sectional view taken along section line **24-24** of FIG. **23**;

FIG. **25** is a bottom perspective view of the staple cartridge shown in FIG. **21**;

FIG. **26** is an enlarged perspective view of the actuation sled, the pushers and the fasteners shown in FIG. **21**;

FIG. **27** is an enlarged perspective view with parts separated of the proximal housing portion and mounting assembly of the disposable loading unit shown in FIG. **19**;

FIG. **28** is an enlarged perspective view of the mounting assembly of the disposable loading unit shown in FIG. **19** mounted to a distal end portion of the proximal housing portion;

FIG. **29** is an enlarged perspective view of the proximal housing portion and the mounting assembly of the disposable loading unit shown in FIG. **19** with the upper housing half removed;

FIG. **30** is a perspective view of the proximal housing portion and the mounting assembly of the disposable loading unit shown in FIG. **19** with the upper housing half removed;

FIG. **31** is a perspective view with parts separated of the axial drive assembly;

FIG. **32** is an enlarged perspective view of the axial drive assembly shown in FIG. **31**;

FIG. **33** is an enlarged perspective view of the proximal end of the axial drive assembly shown in FIG. **31** including the locking device;

FIG. **34** is an enlarged perspective view of the distal end of the axial drive assembly shown in FIG. **31**;

FIG. **35** is an enlarged perspective view of the distal end of the elongated body of the stapling apparatus shown in FIG. **1**;

FIG. **36** is an enlarged perspective view of the locking device shown in FIG. **33**;

FIG. **37** is an enlarged perspective view of a lower housing half of the proximal housing portion of the disposable loading unit shown in FIG. **27**;

FIG. **38** is a side cross-sectional view of the disposable loading unit shown in FIG. **20**;

FIG. **39** is an enlarged view of the indicated area of detail shown in FIG. **38**;

FIG. **40** is a perspective view of the surgical stapling apparatus shown in FIG. **1** with the disposable loading unit of FIG. **19** detached from the elongated body;

FIG. **41** is an enlarged perspective view of the disposable loading unit of FIG. **19** during attachment to the elongated body of the surgical stapling apparatus shown in FIG. **1**;

FIG. **42** is another enlarged perspective view of the disposable loading unit of FIG. **19** during attachment to the elongated body of the surgical stapling apparatus shown in FIG. **1**;

FIG. **43** is a cross-sectional view taken along section line **43-43** of FIG. **41**;

FIG. **43***a* is a side cross-sectional view of the rotation knob, articulation mechanism, and sensing mechanism during insertion of a disposable loading unit into the elongated body of the surgical stapling apparatus;

FIG. **44** is a cross-sectional view taken along section line **44-44** of FIG. **42**;

FIG. **45** is a side cross-sectional view of the distal end of the disposable loading unit of FIG. **1** with tissue positioned between the anvil and clamp assemblies;

FIG. **46** is a side cross-sectional view of the handle assembly with the movable handle in an actuated position;

FIG. **47** is an enlarged view of the indicated area of detail shown in FIG. **46**;

FIG. **48** is a cross-sectional view of the proximal end of the disposable loading unit of FIG. **19** and the distal end of the elongated body of the surgical stapling apparatus shown in FIG. **1** with the control rod in a partially advanced position;

FIG. **49** is a cross-sectional view of the tool assembly of the surgical stapling apparatus shown in FIG. **1** positioned about tissue in the clamped position;

FIG. **50** is a cross-sectional view of the handle assembly of the stapling apparatus of FIG. **1** during the clamping stroke of the apparatus;

FIG. **51** is a side cross-sectional view of the distal end of the tool assembly of the stapling apparatus shown in FIG. **1** during firing of the apparatus;

FIG. **52** is a side cross-sectional view of the distal end of the tool assembly of the stapling apparatus shown in FIG. **1** after firing of the apparatus;

FIG. **53** is a side cross-sectional view of the handle assembly of the apparatus during retraction of the actuation shaft;

FIG. **54** is a side cross-sectional view of the handle assembly of the stapling apparatus during actuation of the emergency release button;

FIG. **55** is a top view of the articulation mechanism of the surgical stapling apparatus;

FIG. **56** is a side cross-sectional view of the articulation mechanism and rotation member of the surgical stapling apparatus shown in FIG. **1**;

FIG. **57** is a top view of the distal end of the elongated body, the mounting assembly, and the proximal end of the tool assembly during articulation of the stapling apparatus;

FIG. **58** is a perspective view of the surgical stapling apparatus during articulation of the tool assembly;

FIG. **59** is a perspective view of the surgical stapling apparatus during articulation and rotation of the tool assembly;

FIG. **60** is a top view of the distal end of the disposable loading unit immediately prior to articulation;

FIG. **61** is a top view of the distal end of the elongated body, the mounting assembly, and the proximal end of the tool assembly during articulation of the stapling apparatus;

FIG. **62** is a partial cross-sectional view of a portion of the disposable loading unit during retraction of the locking device; and

FIG. **63** is a partial cross-sectional view of a portion of the disposable loading unit with the locking device in the locked position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the presently disclosed endoscopic surgical stapling apparatus will now be described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views.

In the drawings and in the description that follows, the term "proximal", as is traditional, will refer to the end of the stapling apparatus which is closest to the operator, while the term distal will refer to the end of the apparatus which is furthest from the operator.

FIGS. **1-3** illustrate one embodiment of the presently disclosed surgical stapling apparatus shown generally as **10**. Briefly, surgical stapling apparatus **10** includes a handle assembly **12** and an elongated body **14**. A disposable loading unit or DLU **16** is releasably secured to a distal end of elongated body **14**. Disposable loading unit **16** includes a tool assembly **17** having a cartridge assembly **18** housing a plurality of surgical staples and an anvil assembly **20** movably secured in relation to cartridge assembly **18**. Disposable loading unit **16** is configured to apply linear rows of staples measuring from about 30 mm to about 60 mm in length. Disposable loading units having linear rows of staples of other lengths are also envisioned, e.g., 45 mm. Handle assembly **12** includes a stationary handle member **22**, a movable handle member **24**, and a barrel portion **26**. A rotatable member **28** is preferably mounted on the forward end of barrel portion **26** to facilitate rotation of elongated body **14** with respect to handle assembly **12**. An articulation lever **30** is also preferably mounted on the forward end of barrel portion **26** adjacent rotatable knob **28** to facilitate articulation of tool assembly **17**. A pair of retraction knobs **32** are movably positioned along barrel portion **26** to return surgical stapling apparatus **10** to a retracted position, as will be described in detail below.

Referring to FIG. **4**, handle assembly **12** includes housing **36**, which is preferably formed from molded housing half-sections **36***a* and **36***b*, which forms stationary handle member **22** and barrel portion **26** of handle assembly **12** (See FIG. **1**). Movable handle member **24** is pivotably supported between housing half-sections **36***a* and **36***b* about pivot pin **38**. A biasing member **40**, which is preferably a torsion spring, biases movable handle **24** away from stationary handle **22**. An actuation shaft **46** is supported within barrel portion **26** of housing **36** and includes a toothed rack **48**. A driving pawl **42** having a rack engagement finger **43** with laterally extending wings **43***a* and **43***b* is pivotably mounted to one end of movable handle **24** about a pivot pin **44**. A biasing member **50**, which is also preferably a torsion spring, is positioned to urge engagement finger **43** of driving pawl **42** towards toothed rack **48** of actuation shaft **46**. Movable handle **24** is pivotable to move engagement finger **43** of driving pawl **42** into contact with toothed rack **48** of actuation shaft **46** to advance the actuation shaft linearly in the distal direction. The forward end of actuation shaft **46** rotatably receives the proximal end **49** of a control rod **52** such that linear advancement of actuation shaft **46** causes corresponding linear advancement of control rod **52**. A locking pawl **54** having a rack engagement member **55** is pivotably mounted within housing **36** about pivot pin **57** and is biased towards toothed rack **48** by biasing member **56**, which is also preferably a torsion spring. Engagement member **55** of locking pawl **54** is movable into engagement with toothed rack **48** to retain actuation shaft **46** in a longitudinally fixed position.

A retraction mechanism **58** which includes a pair of retractor knobs **32** (See FIG. **1**) is connected to the proximal end of actuation shaft **46** by a coupling rod **60**. Coupling rod **60** includes right and left engagement portions **62***a* and **62***b* for receiving retractor knobs **32** and a central portion **62***c* which is dimensioned and configured to translate within a pair of longitudinal slots **34***a* formed in actuation shaft **46** adjacent the proximal end thereof. A release plate **64** is operatively associated with actuation shaft **46** and is mounted for movement with respect thereto in response to manipulation of retractor knobs **32**. A pair of spaced apart pins **66** extend outwardly from a lateral face of actuation shaft **46** to engage a pair of corresponding angled cam slots **68** formed in release plate **64**. Upon rearward movement of retractor knobs **32**, pins **66** can release plate **64** downwardly with respect to actuation shaft **46** and with respect to toothed rack **48** such that the bottom portion of release plate **64** extends below toothed rack **48** to disengage engagement finger **43** of driving pawl **42** from toothed rack **48**. A transverse slot **70** is formed at the proximal end of release plate **64** to accommodate the central portion **62***c* of coupling rod **60**, and elongated slots **34** (See FIG. **1**) are defined in the barrel section **26** of handle assembly **12** to accommodate the longitudinal translation of coupling rod **60** as retraction knobs **32** are pulled rearwardly to retract actuation shaft **46** and thus retract control rod **52** rearwardly. Actuation shaft **46** is biased proximally by spring **72** which is secured at one end to coupling rod portion **62** via connector **74** and at the other end to post **76** on actuation shaft **46**.

Referring also to FIG. **5**, handle assembly **12** includes a firing lockout assembly **80** which includes a plunger **82** and a pivotable locking member **83**. Plunger **82** is biased to a central position by biasing springs **84** and includes, annular tapered camming surfaces **85**. Each end of plunger **82** extends through housing **36** (See FIG. **1**) adjacent an upper end of stationary handle **22**. Pivotable locking member **83** is pivotably attached at its distal end between housing half-sections **36***a* and **36***b* about pivot pin **86** and includes a locking surface **88** and proximal extension **90** having a slot **89** formed therein. Locking member **83** is biased by spring **92** counter-clockwise (as viewed in FIG. **4**) to move locking surface **88** to a position to abut the distal end of actuation shaft **46** to prevent advancement of shaft **46** and subsequent firing of stapling apparatus **10**. Annular tapered camming surface **85** is positioned to extend into tapered slot **89** in proximal extension **90**. Lateral movement of plunger **82** in either direction against the bias of either spring **84** moves tapered camming surface **85** into engagement with the sidewalls of tapered slot **89** to pivot locking member **83** clockwise about pivot pin **86**, as viewed in FIG. **4**, to move blocking surface **88** to a position to permit advancement of actuation shaft **46** and thus firing of stapling apparatus **10**. Blocking surface **88** is retained in this position by recesses **87** which receive the tapered tip of camming surface **85** to lock locking member **83** in a counter-clockwise position. Operation of firing lockout assembly **80** will be further illustrated below.

Referring to FIGS. **4**, **6**, and **7**, handle mechanism **12** also includes an anti-reverse clutch mechanism which includes a first gear **94** rotatably mounted on a first shaft **96**, and second gear **98** mounted on a second shaft **100**, and a slide plate **102** (FIGS. **6** and **7**) slidably mounted within housing **36**. Slide plate **102** includes an elongated slot **104** dimensioned and configured to be slidably positioned about locking pawl pivot pin **57**, a gear plate **106** configured to mesh with the teeth of second gear **98**, and a cam surface **108**. In the retracted position, cam surface **108** of slide plate **102** engages locking pawl **54** to prevent locking pawl **54** from engaging toothed rack **48**. Actuation shaft **46** includes a distal set of gear teeth **110***a* spaced from a proximal set of gear teeth **110***b* positioned to engage first gear **94** of actuation shaft **46** during movement of actuation shaft **46**. When actuation shaft **46** is advanced by pivoting movable handle **24** about pivot pin **38**, distal gear teeth **110***a* on actuation shaft **46** mesh with and rotate first gear **94** and first shaft **96**. First shaft **96** is connected to second shaft **100** by spring clutch assembly such that rotation of first shaft **96** will cause corresponding rotation of second shaft **100**. Rotation of second shaft **100** causes corresponding rotation of second gear **98** which is engaged with gear plate **106** on slide plate **102** to cause linear advancement of slide plate **102**. Linear advancement of slide plate **102** is limited to the length of elongated slot **104**. When slide plate has been advanced the length of slot **104**, cam surface **108** releases locking pawl **54** such that it is moved into engagement with toothed rack **48**. Continued advancement of actuation shaft **46** eventually moves gear teeth **110***b* into engagement with gear plate **106**. However, since slide plate **102** is longitudinally fixed in position, the spring clutch is forced to release, such that continued distal advancement of actuation shaft **46** is permitted.

When actuation shaft **46** is returned to the refracted position (by pulling retraction knobs **34** proximally, as discussed above) gear teeth **110***b* engage first gear **94** to rotate second gear **98** in the reverse direction to retract slide member **102** proximally within housing **36**. Proximal movement of slide member **102** advances cam surface **108** into locking pawl **54** prior to engagement between locking pawl **54** and toothed rack **48** to urge locking pawl **54** to a position to permit retraction of actuation shaft **46**.

Referring again to FIG. **4**, handle assembly **12** includes an emergency return button **112** pivotally mounted within housing **36** about a pivot member **114** supported between housing half-sections **36***a* and **36***b*. Return button **112** includes an externally positioned member **116** positioned on the proximal end of barrel portion **26**. Member **116** is movable about pivot member **114** into engagement with the proximal end of lock-

ing pawl **54** to urge rack engagement member **55** out of engagement with toothed rack **48** to permit retraction of actuation shaft **46** during the firing stroke of the stapling apparatus **10**. As discussed above, during the clamping portion of advancement of actuation shaft **46**, slide plate **102** disengages pawl **54** from rack **48** and thus actuation of return button **112** is not necessary to retract the actuation shaft **46**.

FIG. **8** illustrates the interconnection of elongated body **14** and handle assembly **12**. Referring to FIGS. **8-10**, housing **36** includes an annular channel **117** configured to receive an annular rib **118** formed on the proximal end of rotation member **28**, which is preferably formed from molded half-sections **28***a* and **28***b* Annular channel **117** and rib **118** permit relative rotation between rotation member **28** and housing **36**. Elongated body **14** includes inner housing **122** and an outer casing **124**. Inner housing **122** is dimensioned to be received within outer casing **124** and includes an internal bore **126** (FIG. **8**) which extends therethrough and is dimensioned to slidably receive a first articulation link **123** and control rod **52**. The proximal end of housing **122** and casing **124** each include a pair of diametrically opposed openings **130** and **128**, respectively, which are dimensioned to receive radial projections **132** formed on the distal end of rotation member **28**. Projections **132** and openings **128** and **130** fixedly secure rotation member **28** and elongated body **14** in relation to each other, both longitudinally and rotatably. Rotation of rotation knob **28** with respect to handle assembly **12** thus results in corresponding rotation of elongated body **14** with respect to handle assembly **12**.

An articulation mechanism **120** is supported on rotatable member **28** and includes articulation lever **30**, a cam member **136**, a translation member **138**, and first articulation link **123** (FIG. **9**). Articulation lever **30** is pivotably mounted about pivot member **140** which extends outwardly from rotation member **28** and is preferably formed integrally therewith. A projection **142** extends downwardly from articulation lever **30** for engagement with cam member **136**.

Referring temporarily to FIGS. **11** and **12**, cam member **136** includes a housing **144** having an elongated slot **146** extending through one side thereof and a stepped camming surface **148** formed in the other side thereof. Each step of camming surface **148** corresponds to a particular degree of articulation of stapling apparatus **10**. Although five steps are illustrated, fewer or more steps may be provided. Elongated slot **146** is configured to receive projection **142** formed on articulation lever **30**. Housing **144** includes a distal stepped portion **150** and a proximal stepped portion **152**. Proximal stepped portion **152** includes a recess **154**.

Referring again to FIGS. **8-10** and also to FIGS. **13-15**, translation member **138** includes a plurality of ridges **156** which are configured to be slidably received within grooves **158** formed along the inner walls of rotation member **28**. Engagement between ridges **156** and grooves **158** prevent relative rotation of rotation member **28** and translation member **138** while permitting relative linear movement. The distal end of translation member **138** includes arm **160** which includes an opening **162** configured to receive a finger **164** extending from the proximal end of articulation link **123** (See FIG. **10***a*). A pin **166** having a housing **168** constructed from a non-abrasive material, e.g., teflon, is secured to translation member **138** and dimensioned to be received within stepped camming surface **148**.

In an assembled condition, proximal and distal stepped portions **150** and **152** of cam member **136** are positioned beneath flanges **170** and **172** formed on rotation member **28** to restrict cam member **136** to transverse movement with respect to the longitudinal axis of stapling apparatus **10**. When articulation lever **30** is pivoted about pivot member **140**, cam member **136** is moved transversely on rotation member **28** to move stepped camming surface **148** transversely relative to pin **166**, forcing pin **166** to move proximally or distally along stepped cam surface **148**. Since pin **166** is fixedly attached to translation member **138**, translation member **138** is moved proximally or distally to effect corresponding proximal or distal movement of first actuation link **123**.

Referring to FIGS. **8-10** and **16**, a disposable loading unit sensing mechanism extends within stapling apparatus **10** from elongated body **14** into handle assembly **12**. The sensing mechanism includes a sensor tube **176** which is slidably supported within bore **26** of elongated body **14**. The distal end of sensor tube **176** is positioned towards the distal end of elongated body **14** and the proximal end of sensor tube **176** is secured within the distal end of a sensor cylinder **176** via a pair of nubs **180**. The distal end of a sensor link **182** is secured to the proximal end of sensor cylinder **178**. Sensor link **182** (See FIGS. **8***a* and **8***c*) has a bulbous end **184** which engages a camming surface **83***a* on pivotable locking member **83**. When a disposable loading unit (not shown) is inserted in the distal end of elongated body **14**, the disposable loading unit engages the distal end **177** of sensor tube **176** to drive sensor tube **176** proximally, and thereby drive sensor cylinder **178** and sensor link **182** proximally. Movement of sensor link **182** proximally causes bulbous end **184** of sensor link **182** to move distally of camming surface **83***a* to allow locking member **83** to pivot under the bias of spring **92** from a position permitting firing of stapling apparatus **10** to a blocking position, wherein blocking member **83** is positioned to engage actuation shaft **46** and prevent firing of stapling apparatus **10**. Sensor link **182** and locking member **83** function to prevent firing of surgical stapling apparatus **10** after a disposable loading unit has been secured to elongated body **14**, without first operating firing lockout assembly **80**. It is noted that movement of link **182** proximally permits locking member **83** to move to its position shown in FIG. **5**.

Referring again to FIGS. **9-12**, cam member **136** includes recess **154**. A locking ring **184** having a nub portion **186** configured to be received within recess **154** is positioned about sensor cylinder **178** between a control tab portion **188** and a proximal flange portion **190**. A spring **192** positioned between flange portion **190** and locking ring **184** urges locking ring distally about sensor cylinder **178**. When an articulating disposable loading unit **16***b* having an extended insertion tip **193** is inserted into the distal end of elongated body **14** of stapling apparatus **10**, insertion tip **193** causes tab portion **188** to move proximally into engagement with locking ring **184** to urge locking ring **184** and nub **186** proximally of recess **154** in cam member **136** (See FIG. **12***b*). With nub **186** positioned proximally of recess **154**, cam member **136** is free to move transversely to effect articulation of stapling apparatus **10**. A non-articulating disposable loading unit does not have an extended insertion tip (See FIG. **12***a*). As such, when a non-articulating disposable loading unit is inserted in elongated body **14**, sensor cylinder **178** is not retracted proximally a sufficient distance to move nub **186** from recess **154**. Thus, cam member **136** is prevented from moving transversely by nub **186** of locking ring **184** which is positioned in recess **154** and articulation lever **30** is locked in its central position.

Referring to FIGS. **16-18**, the distal end of elongated body **14** includes a control rod locking mechanism **190** which is activated during insertion of a disposable loading unit into elongated body **14**. Control rod locking mechanism **190** includes a blocking plate **192** which is biased distally by a spring **194** and includes a proximal finger **189** having angled

cam surface **195**. A semi-circular engagement member **196** is biased transversely towards control rod **52** by a spring **197**. Control rod **52** includes an annular recess **199** configured to receive engagement member **196**. Blocking plate **192** is movable from a distal position spaced from engagement member **196** to a proximal position located behind engagement member **196**. In the proximal position, engagement member **196** is prevented from being biased from recess **199** by engagement with blocking plate **192**. During insertion of a disposable loading unit **16** (See FIG. **1**) into the distal end of elongated body **14**, as will be described in further detail below, cam surface **195** of blocking plate **192** is engaged by a nub **254** (FIG. **30**) on the disposable loading unit **16** as the disposable loading unit is rotated into engagement with elongated body **14** to urge plate **192** to the proximal position. Engagement member **196**, which is positioned within recess **199**, is retained therein by blocking plate **192** while nub **254** engages cam surface **195** to prevent longitudinal movement of control rod **52** during assembly. When the disposable loading unit **16** is properly positioned with respect to the elongated body **14**, nub **254** on the proximal end of the disposable loading unit **16** passes off cam surface **195** allowing spring **194** to return blocking plate **192** to its distal position to permit subsequent longitudinal movement of control rod **52**. It is noted that when the disposable loading unit nub passes off cam surface **195**, an audible clicking sound is produced indicating that the disposable loading unit **16** is properly fastened to the elongated body **14**.

Referring to FIGS. **19** and **20**, disposable loading unit **16** includes a proximal housing portion **200** adapted to releasably engage the distal end of body portion **14** (FIG. **1**). A mounting assembly **202** is pivotally secured to the distal end of housing portion **200**, and is configured to receive the proximal end of tool assembly **17** such that pivotal movement of mounting assembly **202** about an axis perpendicular to the longitudinal axis of housing portion **200** effects articulation of tool assembly **17**.

Referring to FIGS. **21-26**, tool assembly **17** preferably includes anvil assembly **20** and cartridge assembly **18**. Anvil assembly **20** includes anvil portion **204** having a plurality of staple deforming concavities **206** (FIG. **22**) and a cover plate **208** secured to a top surface of anvil portion **204** to define a cavity **210** (FIG. **24**) therebetween. Cover plate **208** is provided to prevent pinching of tissue during clamping and firing of stapling apparatus **10**. Cavity **210** is dimensioned to receive a distal end of an axial drive assembly **212** (See FIG. **27**). A longitudinal slot **214** extends through anvil portion **204** to facilitate passage of retention flange **284** of axial drive assembly **212** into the anvil cavity **210**. A camming surface **209** formed on anvil portion **204** is positioned to engage axial drive assembly **212** to facilitate clamping of tissue **198**. A pair of pivot members **211** formed on anvil portion **204** are positioned within slots **213** formed in carrier **216** to guide the anvil portion between the open and clamped positions. A pair of stabilizing members **215** engage a respective shoulder **217** formed on carrier **216** to prevent anvil portion **204** from sliding axially relative to staple cartridge **220** as camming surface **209** is deformed.

Cartridge assembly **18** includes a carrier **216** which defines an elongated support channel **218**. Elongated support channel **218** is dimensioned and configured to receive a staple cartridge **220**. Corresponding tabs **222** and slots **224** formed along staple cartridge **220** and elongated support channel **218** function to retain staple cartridge **220** within support channel **218**. A pair of support struts **223** formed on staple cartridge **220** are positioned to rest on side walls of carrier **216** to further stabilize staple cartridge **220** within support channel **218**.

Staple cartridge **220** includes retention slots **225** for receiving a plurality of fasteners **226** and pushers **228**. A plurality of spaced apart longitudinal slots **230** extend through staple cartridge **220** to accommodate upstanding cam wedges **232** of actuation sled **234**. A central longitudinal slot **282** extends along the length of staple cartridge **220** to facilitate passage of a knife blade **280**. During operation of surgical stapler **10**, actuation sled **234** translates through longitudinal slots **230** of staple cartridge **220** to advance cam wedges **232** into sequential contact with pushers **228**, to cause pushers **228** to translate vertically within slots **224** and urge fasteners **226** from slots **224** into the staple deforming cavities **206** of anvil assembly **20**.

Referring to FIGS. **27** and **28**, mounting assembly **202** includes upper and lower mounting portions **236** and **238**. Each mounting portion includes a threaded bore **240** on each side thereof dimensioned to receive threaded bolts **242** (See FIG. **21**) for securing the proximal end of carrier **216** thereto. A pair of centrally located pivot members **244** (See FIG. **21**) extends between upper and lower mounting portions via a pair of coupling members **246** which engage the distal end of housing portion **200**. Coupling members **246** each include an interlocking proximal portion **248** configured to be received in grooves **250** formed in the proximal end of housing portion **200** to retain mounting assembly **202** and housing portion **200** in a longitudinally fixed position in relation thereto.

Housing portion **200** of disposable loading unit **16** includes an upper housing half **250** and a lower housing half **252** contained within an outer casing **251**. The proximal end of housing half **250** includes engagement nubs **254** for releasably engaging elongated body **14** and an insertion tip **193**. Nubs **254** form a bayonet type coupling with the distal end of body **14** which will be discussed in further detail below. Housing halves **250** and **252** define a channel **253** for slidably receiving axial drive assembly **212**. A second articulation link **256** is dimensioned to be slidably positioned within a slot **258** formed between housing halves **250** and **252**. A pair of blow out plates **255** are positioned adjacent the distal end of housing portion **200** adjacent the distal end of axial drive assembly **212** to prevent outward bulging of drive assembly **212** during articulation of tool assembly **17**. Each blow-out plate **255**, as illustrated in FIGS. **27**, **57**, **60** and **61**, includes a planar surface which is substantially parallel to the pivot axis of tool assembly **17** and is positioned on a side of drive assembly **212** and the pivot axis to prevent outward bulging of drive assembly **212**. Each blow-out plate includes a first distal bend **255***a* which is positioned in a respective first groove **202***a* formed in mounting assembly **202** and a second proximal bend **255***b* which is positioned in a respective second groove **200***a* formed in a distal end of housing portion **200**.

Referring to FIGS. **29-30**, second articulation link **256** includes at least one elongated metallic plate. Preferably, two or more metallic plates are stacked to form link **256**. The proximal end of articulation link **256** includes a hook portion **258** configured to engage first articulation link **123** (See FIG. **9**) and the distal end includes a loop **260** dimensioned to engage a projection **262** formed on mounting assembly **202**. Projection **262** is laterally offset from pivot pin **244** such that linear movement of second articulation link **256** causes mounting assembly **202** to pivot about pivot pins **244** to articulate tool assembly **17**.

Referring also to FIGS. **31-34**, axial drive assembly **212** includes an elongated drive beam **266** including a distal working head **268** and a proximal engagement section **270**. Drive

beam **266** may be constructed from a single sheet of material or, preferably, multiple stacked sheets. Engagement section **270** includes a pair of engagement fingers **270***a* and **270***b* which are dimensioned and configured to mountingly engage a pair of corresponding retention slots **272***a* and **272***b* formed in drive member **272**. Drive member **272** includes a proximal porthole **274** configured to receive the distal end **276** of control rod **52** (See FIG. **35**) when the proximal end of disposable loading unit **16** is engaged with elongated body **14** of surgical stapling apparatus **10**.

The distal end of drive beam **266** is defined by a vertical support strut **278** which supports a knife blade **280**, and an abutment surface **283** which engages the central portion of actuation sled **234** during a stapling procedure. Surface **285** at the base of surface **283** is configured to receive a support member **287** slidably positioned along the bottom of the staple cartridge **220**. Knife blade **280** is positioned to translate slightly behind actuation sled **234** through a central longitudinal slot **282** in staple cartridge **220** (FIG. **30**) to form an incision between rows of stapled body tissue. A retention flange **284** projects distally from vertical strut **278** and supports a cylindrical cam roller **286** at its distal end. Cam roller **286** is dimensioned and configured to engage cam surface **209** on anvil body **204** to clamp anvil portion **204** against body tissue.

Referring also to FIGS. **36-39**, a locking device **288** is pivotally secured to drive member **270** about a pivot pin **290**. Locking device **288** includes a pair of elongate glides **292** and **294** which define a channel **296**. A web **298** joins a portion of the upper surfaces of glides **292** and **294**, and is configured and dimensioned to fit within elongated slot **298** formed in drive beam **266** at a position distal of drive member **270**. Horizontal cams **300** and **302** extend from glides **292** and **294** respectively, and are accommodated along an inner surface of lower housing half **252**. As best shown in FIG. **42**, a torsion spring **304** is positioned adjacent drive member **270** and engages horizontal cams **300** and **302** of locking device **288** to normally bias locking device **288** downward toward lower housing half **252** onto ledge **310**. Locking device **288** translates through housing portion **200** with axial drive assembly **212**. Operation of locking device **288** will be described below.

Sequence of Operation

Referring to FIGS. **40-44**, to use stapling instrument **10**, a disposable loading unit **16** is first secured to the distal end of elongated body **14**. As discussed above, stapling instrument **10** can be used with articulating and non-articulating disposable loading units having linear rows of staples between about 30 mm and about 60 mm. To secure disposable loading unit **16** to elongated body **14**, the distal end **276** of control rod **52** is inserted into insertion tip **193** of disposable loading unit **16**, and insertion tip **193** is slid longitudinally into the distal end of elongated body **14** in the direction indicated by arrow "A" in FIG. **41** such that hook portion **258** of second articulation link **256** slides within a channel **310** in elongated body **314**. Nubs **254** will each be aligned in a respective channel (not shown) in elongated body **14**. When hook portion **258** engages the proximal wall **312** of channel **310**, disposable loading unit **16** is rotated in the direction indicated by arrow "B" in FIGS. **41-44** to move hook portion **258** of second articulation link **256** into engagement with finger **164** of first articulation link **123**. Nubs **254** also forms a bayonet type coupling within annular channel **314** in body **14**. During rotation of loading unit **16**, nubs **254** engage cam surface **195** (FIG. **41**) of block plate **192** to initially move plate **192** in the direction indicated by arrow "C" in FIGS. **41** and **43** to lock engagement member **196** in recess **199** of control rod **52** to prevent longitudinal movement of control rod **52** during attachment of disposable loading unit **16**. During the final degree of rotation, nubs **254** disengage from cam surface **195** to allow blocking plate **192** to move in the direction indicated by arrow "D" in FIGS. **42** and **44** from behind engagement member **196** to once again permit longitudinal movement of control rod **52**.

Referring to FIGS. **43** and **43***a*, when insertion tip **193** engages the distal end of sensor tube **176**, the disposable loading unit sensing mechanism is actuated. Insertion tip **193** engages and moves sensor tube **176** proximally in the direction indicated by arrow "E" in FIG. **43**. As discussed above, proximal movement of sensor tube **176** effects proximal movement of sensor cylinder **178** and sensor link **182** in the direction indicated by arrow "E" in FIG. **43***a* to pivot locking member **83** counter-clockwise, as indicated by arrow "Y" in FIG. **43***a*, from a non-blocking position to a position blocking movement of actuation shaft **46**.

Referring to FIGS. **46-49**, with a disposable loading unit attached to stapling instrument **10**, tool assembly **17** can be positioned about tissue **320** (FIG. **45**). To clamp tissue between anvil assembly **20** and cartridge assembly **18**, stationary handle **24** is moved in the direction indicated by arrow "E" in FIG. **46** against the bias of torsion spring **40** to move driving pawl **42** into engagement with shoulder **322** on actuation shaft **46**. Engagement between shoulder **322** and driving pawl **42** advances actuation shaft **46** and thus advances control rod **52** distally. Control rod **52** is connected at its distal end to axial drive assembly **212** (FIG. **48**), including drive beam **266**, such that distal movement of control rod **52** effects distal movement of drive beam **266** in the direction indicated by arrow "F" in FIGS. **48** and **49**, moving cam roller **286** into engagement with cam surface **209** on anvil portion **204** to urge anvil portion **204** in the direction indicated by arrow "G" in FIG. **49**. It is noted that one complete stroke of movable handle **24** advances actuation shaft **46** approximately 15 mm which is sufficient to clamp tissue during the first stroke but not to fire staples.

As discussed above with respect to the anti-reverse clutch mechanism, during the first (clamping) stroke of movable handle **24**, slide plate **102** (FIG. **46**) prevents locking pawl **54** from engaging toothed rack **48**. To maintain actuation shaft **46** in its longitudinal position after handle **24** is released, an engagement member **324** (FIG. **47**) is provided on locking member **83** to engage shoulder **326** on actuation shaft **46** and retain shaft **46** in its longitudinal position (See FIG. **47**). Upon release of movable handle **24**, drive pawl **42** moves over rack **48** as torsion spring **40** returns handle **24** to a position spaced from stationary handle **22**. In this position, driving pawl **42** is urged into engagement with toothed rack **48** to retain actuation shaft **46** in its longitudinal fixed position.

In order to fire staples, movable handle **24** is actuated again, i.e., moved through another stroke. As discussed above, stapling apparatus **10** is capable of receiving disposable loading units having linear rows of staples of between about 30 mm and about 60 mm. Since each stroke of the movable handle **24** preferably advances actuation shaft **46** 15 mm, and one stroke is required to clamp tissue, the movable handle must be actuated (n+1) strokes to fire staples, where n is the length of the linear rows of staples in the disposable loading unit attached to stapling instrument **10** divided by 15 mm.

Referring to FIG. **50**, prior to being able to fire staples, firing lockout assembly **80** (FIG. **4**) must be actuated to move locking surface **88** from its blocking position (FIG. **47**) to a non-blocking position. This is accomplished by pressing down on plunger **82** to move camming surface **85** into engagement with sidewalls of slot **89** of locking member **83** to pivot locking member **83** in the direction indicated by arrow

"G" in FIG. **50** (see also FIG. **5**). Thereafter, movable handle **24** may be actuated an appropriate number of strokes to advance actuation shaft **46**, and thus control rod **52** and drive beam **266**, distally in the direction indicated by arrow "H" in FIGS. **51** and **52** to advance actuation sled **234** through staple cartridge **220** to effect ejection of staples. It is noted that after the first or clamping stroke of movable handle **54** (during the second stroke), slide **102** passes over locking pawl **54** allowing torsion spring **56** to move locking pawl **54** in the direction indicated by arrow "I" in FIG. **50** into engagement with toothed rack **48** to retain actuation shaft **46** in its longitudinal position.

Referring to FIG. **53**, to retract actuation shaft **46** and thus control rod **52** and drive member **266** after firing staples, retraction knobs **32** (see FIG. **1**) are pulled proximally causing pins **66** to move release plate **64** in the direction indicated by arrow "J" in FIG. **53** over teeth **48** to disengage drive pawl **42** from engagement with teeth **48**. As discussed above, with respect to the anti-reverse clutch mechanism, locking pawl **54** is urged by slide plate **102** out of engagement with toothed rack **48** (not shown) to permit actuation shaft **46** to be moved proximally, in the direction indicated by arrow "L", after drive pawl **42** is disengaged from teeth **48**.

Referring to FIG. **54**, in order to retract actuation shaft **46** prior to firing stapling apparatus, i.e., when locking pawl is currently engaged with toothed racked **48**, emergency return button **112** is pushed in the direction indicated by arrow "Z" in FIG. **54** to disengage locking pawl **54** from toothed rack **48**. Retraction knobs **32** (FIG. **1**) must also be concurrently pulled rearwardly, as discussed above, to release drive pawl **42** from rack **48**.

Referring to FIGS. **55-61**, when an articulating disposable loading unit is secured to elongated body **14** and articulation lever **30** is pivoted in the direction indicated by arrow "M" in FIG. **55**, cam member **136** is moved transversely by projection **142** (FIG. **10**) in the direction indicated by arrow "N" between flanges **170** and **172** of rotation knob **28**. Since translation member **138** is prevented from rotating by ridges **156** (FIG. **13**), pin **166**, which is fixedly secured to translation member **138**, is forced to move along stepped cam surface **148**. Movement of pin **166** causes corresponding movement of translation member **138** in the direction indicated by arrow "P" in FIGS. **55** and **56** to advance first articulation link **123** in the distal direction. The distal end of first articulation link **123** engages the proximal end of second articulation link **256** (FIG. **42**) which is connected to projection **262** on mounting assembly **202** to advance second link **256** in the direction indicated by arrow "Q" in FIG. **57**. Projection **262** is laterally offset from pivot members **244**, such that distal advancement of second articulation link **256** causes mounting assembly **202** and thus tool assembly **17** to pivot in the direction indicated by arrow "R" in FIGS. **57** and **58**. Note in FIG. **59** that rotation member **28** can be rotated to rotate elongated body **14** about its longitudinal axis while tool assembly **17** is articulated.

FIGS. **60-61** illustrate articulation of tool assembly **17** in the opposite direction to that described above. When second articulation link **256** is retracted by rotating articulation lever **30** in a counter-clockwise direction (not shown) as viewed in FIG. **55**, pin **66** is forced to move proximally along stepped camming surface **148**, moving translation member **138** and first articulation link **123** proximally. Movement of first articulation link **123** proximally, causes second articulation link **256** to move proximally as indicated by arrow "S" in FIG. **58**, to rotate tool assembly **17** in a clockwise direction, as indicated by arrow "T" in FIG. **61**.

Referring to FIG. **12**, movement of pin **166** (FIG. **9**) between adjacent step portions **340** causes tool assembly **17** to articulate 22.5 degrees. Camming surface **148** includes five step portions **340**. The third step portion corresponds to the non-articulated tool assembly position, whereas the first and the fifth step portions correspond to articulation of tool assembly **17** to forty-five degrees. Each step portion is flat to retain articulation lever **30** in a fixed position when pin **166** is engaged therewith.

Referring now to FIGS. **37**, **39**, **62** and **63**, the sequence of lockout operation will be described in detail. In FIG. **39**, lockout device **288** is shown in its prefixed position with horizontal cams **300** and **302** resting on top of projections **330** formed in the sidewalls of lower housing half **252** (FIG. **37**). In this position, locking device **288** is held up out of alignment with projection **332** formed in the bottom surface of lower housing half **252**, and web **298** is in longitudinal juxtaposition with shelf **334** defined in drive beam **266**. This configuration permits the anvil **20** (FIG. **38**) to be opened and repositioned onto the tissue to be stapled until the surgeon is satisfied with the position without activating locking device **288** to disable the disposable loading unit **16**.

As shown in FIG. **62**, upon distal movement of drive beam **266**, locking device **288** rides off of projections **330** (not shown) and is biased into engagement with base lower housing half **252** by spring **304**, distal to projection **332**. Locking device **288** remains in this configuration throughout firing of the apparatus.

Upon retraction of the drive beam **266** in the direction indicated by arrow "U" in FIG. **62**, locking device **288** passes under projections **330** and rides over projection **332** until the distalmost portion of locking device **288** is proximal to projection **332**. Spring **304** biases locking device **288** into juxtaposed alignment with projection **332**, effectively disabling the disposable loading unit. If an attempt is made to reactuate the apparatus, the control rod **52** will abut a proximal end surface of locking device **288** which surface is diagonally sloped to impart a moment about pivot pin **342** such that the distal end of locking device **288** is rotationally urged into contact with projection **332**. Continued distal force in the direction indicated by arrow "W" in FIG. **63**, will only serve to increase the moment applied to the locking device thus the locking device will abut projection **332** and inhibit distal movement of the control rod **52**.

Referring again to FIGS. **41-44**, the disabled or locked disposable loading unit can be removed from the distal end of elongated body **14** by rotating disposable loading unit **16** in the direction opposite to the direction indicated by arrow "B" in FIGS. **41**, **42** and **44**, to disengage hook portion **258** of second articulation link **256** from finger **164** of first articulation link **123**, and to disengage nubs **254** from within channel **314** of elongated body **14**. After rotation, disposable loading unit **16** can be slid in the direction opposite to that indicated by arrow "A" in FIG. **41** to detach body **14** from disposable loading unit **16**. Subsequently, additional articulating and/or non-articulating disposable loading units can be secured to the distal end of elongated body, as described above, to perform additional surgical stapling and/or cutting procedures. As discussed above, each disposable loading unit may include linear rows of staples which vary from about 30 mm to about 60 mm.

It will be understood that various modifications may be made to the embodiments disclosed herein. For example, the stapling apparatus need not apply staples but rather may apply two part fasteners as is known in the art. Further, the length of the linear row of staples or fasteners may be modified to meet the requirements of a particular surgical procedure. Thus, the

length of a single stroke of the actuation shaft and/or the length of the linear row of staples and/or fasteners within a disposable loading unit may be varied accordingly. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended thereto.

While the invention has been illustrated and described as embodied in an apparatus and method for performing surgical tasks, it is not intended to be limited to the details shown, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and its operation can be made by those skilled in the art without departing in any way from the spirit or scope of the appended claims.

What is claimed is:

1. A method of performing a surgical procedure comprising:

inserting a disposable loading unit into a distal end of an elongate body;

causing the disposable loading unit to engage a sensing mechanism supported within the elongate body;

displacing a portion of the sensing mechanism to permit movement of a locking member from a first position, wherein the locking member is positioned to permit firing of the disposable loading unit, to a second position, wherein the locking member is positioned to inhibit firing of the disposable loading unit;

manipulating a lockout assembly to permit the locking member to return to the first position, and thereby permit firing of the disposable loading unit; and

firing the disposable loading unit to apply one or more surgical fasteners to tissue.

2. The method of claim **1**, wherein displacing the portion of the sensing mechanism includes overcoming a bias applied to the locking member by a biasing member.

3. The method of claim **1**, wherein displacing the portion of the sensing mechanism includes sliding the portion of the sensing mechanism within the elongate body.

4. The method of claim **3**, wherein displacing the portion of the sensing mechanism includes sliding a sensor tube within the elongate body.

5. The method of claim **4**, wherein causing the disposable loading unit to engage the sensing mechanism includes causing the disposable loading unit to engage a distal end of the sensor tube.

6. The method of claim **4**, wherein sliding the sensor tube within the elongate body includes sliding the sensor tube in a proximal direction away from an end effector of the disposable loading unit.

7. The method of claim **6**, wherein sliding the sensor tube within the elongate body includes causing a sensor cylinder and a sensor link to move in the proximal direction away from the end effector of the disposable loading unit.

8. The method of claim **7**, wherein moving the sensor link in the proximal direction includes causing an end of the sensor link to move distally to permit movement of the locking member from the first position to the second position.

9. The method of claim **8**, wherein moving the sensor link in the proximal direction includes causing the end of the sensor link to move distally of a camming surface formed on the locking member.

10. The method of claim **1**, wherein displacing the portion of the sensing mechanism includes moving the locking member into engagement with an actuation shaft.

* * * * *